

THE UNIVERSITY OF KANSAS SCIENCE BULLETIN

VOL. XL]

APRIL 20, 1960

[No. 6

Comparative External Morphology and Taxonomy of Nymphs of the Trombiculidae (Acarina)¹

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ABSTRACT: Laboratory reared nymphs of 46 species of trombiculid mites were used as the basis for morphological and taxonomic studies. The nymphs are free-living and are rarely collected. Chigger mites, the larvae of trombiculids, are commonly found as ectoparasites on many species of vertebrates. Until recently the classification of these mites has been based almost entirely on the larval stage.

Only a few of the known species were available as nymphs; these were members of the genera *Acomatacarus* (2 species), *Chatia* (1 species), *Hanne-
mania* (3 species), *Lecuwenhoekia* (1 species), *Whartonia* (1 species), *Blankaartia* (2 species), *Cheladonta* (2 species), *Euschöngastia* (8 species), *Euschöngastoides* (2 species), *Neoschöngastia* (2 species), *Pseudoschöngastia* (2 species), *Speleocola* (1 species), *Trombicula* (18 species), and *Walchia* (1 species). The morphological work was directed towards the discovery of useful taxonomic characters. When discovered these characters were used to provide diagnoses and keys for subfamilies, genera, subgenera, and species, in a system essentially similar to those based on larvae. Few changes in the classification were made; these were the suppression of the subfamily Walchiinae as a synonym of Trombiculinae, the elevation of *Euschöngastoides* to generic rank, and the transfer of *Euschöngastia loomisi* to that genus.

A comparison of the classification based on nymphs with that based on larvae shows that most genera are distinct, *i. e.*, recognizable by a character or group of characters, in both larval and nymphal stages. The degree of distinctiveness often is not the same in the two stages. No characters were found in the nymphal stage which can be used to diagnose the subgenus *Neotrombicula* (genus *Trombicula*); however, relationships do not seem to be contrary to those shown in the larval stage. In such cases the two systems of classification are in basic agreement. A more serious discrepancy concerns the genus *Euschöngastoides*. Larvae of the two included species fall into two different genera but the nymphs are similar to each other and are amply distinct from

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other species. In this instance the difficulty appears to lie in the use of a single key character which separates two otherwise similar larvae into different genera.

It is proposed that characters of postlarval stages should be considered as additional evidence in the taxonomy of these mites, and that neither larval nor postlarval stages should be given undue weight. While larva and postlarva are adapted to different modes of existence there appears to be no base for weighing characters of any particular stage.

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INTRODUCTION

This paper presents the results of a comparative study of the external morphology of the nymphal stage of the available species of trombiculid mites, with the purpose of evaluating morphological features as specific and as group characters, and presenting workable descriptions of the nymphs studied. This work is necessarily of a preliminary nature and more detailed studies of some features will no doubt produce further valuable information. An attempt was made to include as many species as possible, but nymphs of only a small fraction of the described species were available. Moreover, some of the species included are represented by but one or two specimens. It is hoped that this study will provide a basis for other workers in preparing descriptions and in discerning group characters and features distinguishing the higher categories.

This study is restricted almost entirely to American species, for practical reasons. Nymphs from other regions have been and are

being studied by other workers, including Audy in Malaya, Domrow and Womersley in Australia, Lipovsky and others for Korea, Sasa in Japan, and Vercammen-Grandjean in Africa.

The virtual restriction of this paper to one geographic area seems to preclude any extensive revision of the extant classification based on larvae, since the latter is based on the fauna of all regions. The taxonomic effects of postlarval characters on the larval classification is assessed but changes in the formal classification are kept to a minimum.

The nymphal stage rather than the adult stage was selected for study due to several considerations. The nymph differs from the adult in only three major ways: it is of smaller size, has fewer setae, and has incompletely developed genitalia (Wharton and Fuller, 1952:39). The reduced number of setae is actually an advantage since study of variation of their number is greatly simplified. Preliminary studies of adult genitalia failed to reveal characters of value in distinguishing groups, although characters of this type quite possibly are present. Thus little is lost in choosing the nymphal stage rather than the adult. Moreover, nymphs may be obtained from engorged larvae with relative ease, while the rearing of adults requires not only suitable culture conditions but a food material for the nymphs as well. The proper food for postlarval stages is still a major deterrent in rearing trombiculids (Wharton and Fuller, 1952:24) although much progress has been made towards overcoming this difficulty (Lipovsky, 1954:945). By choosing nymphs instead of adults, a greater number of species, represented by more specimens, was available for study.

In contrast to the larval stage, knowledge of the form and habits of the free-living postlarval stages has only recently been acquired. Although trombiculid adults are but rarely collected in nature, in the past ten years rearing techniques have been devised so that nymphs and adults may be reared from engorged larvae taken from hosts. However, taxonomic descriptions of reared adults, properly associated with their larval stage, have been slow to appear in the literature, and most of the published descriptions are somewhat superficial and inadequate for recognition of the species. Accurate and complete accounts of postlarval stages are restricted to a few species, but these have been made the basis of considerable generalization.

ACKNOWLEDGMENTS

I wish to express my gratitude to those persons who contributed ideas, efforts, and specimens to this work. I am particularly indebted to the staff and students of the department of Entomology, University of Kansas, for such assistance.

To the members of the University of Kansas Chigger Project, I extend my thanks for information, advice, and specimens. I am especially grateful to Dr. Richard B. Loomis and Mr. Louis J. Lipovsky without whose enthusiastic cooperation this work would not have been possible.

For the direction of this work I thank Drs. Robert E. Beer and Charles D. Michener, Department of Entomology, University of Kansas. Also, I am grateful to Dr. Henry S. Fitch, Department of Zoology, for critically reading the manuscript.

This work was supported by a grant (E-476R) from the National Microbiological Institute, National Institutes of Health, U. S. Public Health Service.

HISTORICAL ACCOUNT

The history of the development of knowledge of trombiculids has been reviewed in several recent publications (Wharton and Fuller, 1952; Womersley, 1952, and others); an account of recent developments should suffice for the purposes of this paper.

Three major evaluations of the Trombiculidae have been published recently, all of which consider both larvae and postlarvae. Wharton and Fuller (1952) presented a classification based on larvae; but it utilizes some postlarval features and includes some partial postlarval diagnoses. This effort summarizes our knowledge of trombiculids and includes detailed synonymies for each species. Womersley (1952) revised the Trombiculidae (of Womersley, Trombiculinae of others) by the use of postlarval evidence. Womersley places greater emphasis on postlarval stages than on larvae and deduces from postlarval evidence that some larval characters which were formerly given generic value may be of no more than specific significance. Audy (1954) discusses characters of both larvae and postlarvae, and comments on various genera. These comments are based largely on postlarvae studied by him. Unfortunately the descriptions of the nymphs mentioned have not yet been published. Audy steers a course between the first two authors cited and apparently has adopted the better features of each.

These papers indicate a trend towards a biologically realistic classification of trombiculids, through a consideration of the characters provided by all stages of the life history.

POSITION OF THE NYMPHAL STAGE IN THE LIFE HISTORY

The stages in the life history of trombiculid mites are egg, deutovum, larva, prenymp (nymphochrysalis), nymph, preadult (imagochrysalis), and adult. The larva, nymph, and adult are active stages; the egg, deutovum, prenymp, and preadult are inactive stages in which development occurs. The larvae are parasitic upon terrestrial vertebrates. The nymphs and adults are free-living and predaceous upon small arthropods and their eggs.

The nymph is the first free-living active stage in the life history. If it cannot endure the physical conditions of the habitat in which it finds itself, or cannot find or compete for food materials, it must eventually perish. The adult, also free-living, probably has much the same requirements as the nymph (laboratory cultures so indicate). Characters of the free-living stages may be considered to be tested first by selection in the nymphal stage and those individuals insufficiently adapted to the particular environment never reach the adult stage and hence never reproduce.

It has been shown that trombiculid larvae, while not host-specific, may occur in greater abundance on one or a few particular hosts. For example, Loomis (1955:255) shows that *Trombicula gurneyi* larvae are found on several reptilian and mammalian hosts, but are found with greater frequency and in greater numbers on those closely associated with decaying logs. The adults have been found in decaying logs, and unattached larvae have been taken from this habitat. The skink, *Eumeces fasciatus*, is closely restricted to this habitat, and consequently a greater percentage of larvae, which detach from this host will find a more suitable habitat, than will those which detach from the rattlesnake, *Crotalus horridus*, not so associated with decaying logs. However, the larvae can apparently engorge themselves successfully on either of these two hosts or on others.

Thus the larval stage seems to serve primarily as a means of dispersal. The nymphal and adult stages might be considered as an "anchor" which binds the species to a particular ecological situation and the larva to a particular set of host relationships.

From these considerations it appears that the nymphal stage is at least as critical as the other stages of the life history. Taxonomic characters of this stage should be as valuable and as stable as the characters of the larva and adult. Of course, a sound classification

must admit taxonomic characters of all stages. It is not proposed that nymphal features should be given more weight than those of any other stage.

MATERIALS AND METHODS

The specimens used in this work were mostly reared from engorged larvae taken from vertebrate hosts. A few nymphs were collected from soil, rodent nests, decaying wood, or from beneath rocks. Methods used in the collection of host animals and in removal of chiggers have been described in detail by Loomis (1956:1218).

Living engorged chiggers were placed in culture dishes or tubes lined with a mixture of charcoal and plaster of Paris (Lipovsky, 1953:4). Nymphs were preserved several days after emergence, and were identified from larval specimens associated with them. In later stages of the work, isolation tubes were found to be valuable. These were made from 1-dram vials by addition of a small amount of the charcoal-plaster of Paris mixture. Inactive engorged larvae were transferred singly from larger culture vials into these isolation tubes. After the nymph had emerged, the larval skin could then be mounted for identification of the specimen. The skin was usually found without difficulty.

Specimens were mounted on standard microscope slides for study. Polyvinyl alcohol with lacto-phenol was used as a mounting medium and was found to be satisfactory; however, preliminary clearing of the specimen in hot lacto-phenol produced better slides than did mounting directly from alcohol. Mounts of living material were usually inferior to mounts of material preserved in alcohol for several days.

A phase-contrast microscope was used for detailed study of the specimens. Drawings were made with the aid of a camera lucida. Measurements of structures were made with an ocular micrometer of the fixed type.

In the preparation of mites for taxonomic study customary procedure includes clearing of the soft internal parts so that only skeletal structures remain. This procedure was followed in this study so no description of the soft anatomy can be given. The account is not entirely restricted to external anatomy, however, since the few sclerotized internal structures remain after clearing. Such internal structures, associated with the gnathosoma and genitalia, are included in the following discussions.

Nymphs of forty-six species of trombiculids are included in this paper. A list of these species is presented below, modified by some changes in classification. In the ensuing discussions the evidence for these changes will be presented. It is somewhat less than logical to present the classification and the changes before presenting the evidence for them, but this course may be justified by the saving of space and by the continuity obtained.

Unfortunately some species are represented by only one or a few specimens. It is hoped that the knowledge of variability gained from longer series of other species has enabled the author to avoid gross errors in characterizing these forms.

No specimens of members of the subfamily Apoloniinae were available for study, so that this group is necessarily excluded from the discussions.

Family Trombiculidae Ewing

Subfamily Leeuwenhoekiiinae Womersley

Acomatacarus (Acomatacarus) arizonensis Ewing

Acomatacarus (Xenacarus) plumosus Greenberg

Chatia setosa Brennan

Hannemania dumni Sambon

Hannemania eltoni Sambon

Hannemania multifemorala Loomis

Leeuwenhoekia (Comatacarus) americana (Ewing)

Whartonia senase (Greenberg)

Subfamily Trombiculinae Ewing

Blankaartia alleei (Ewing)

Blankaartia velascoi (Boshell and Kerr)

Cheladonta micheneri Lipovsky, Crossley, and Loomis

Cheladonta ouachitensis Lipovsky, Crossley, and Loomis

Euschöngastia criceticola Brennan

Euschöngastia cynomyicola Crossley and Lipovsky

Euschöngastia diversa Loomis

Euschöngastia jonesi Loomis

Euschöngastia peromysci (Ewing)

Euschöngastia pipistrelli Brennan

Euschöngastia setosa (Ewing)

Euschöngastia trigenuala Loomis

Euschöngastoides hoplai (Loomis)

Euschöngastoides loomisi (Crossley and Lipovsky)

Neoschöngastia americana (Hirst)

- Neoschöngastia brennani* Crossley and Loomis
Pseudoschöngastia farneri Lipovsky
Pseudoschöngastia hungerfordi Lipovsky
Spelcocola tadaridae Lipovsky
Trombicula (Eutrombicula) alfreddugèsi (Oudemans)
Trombicula (Eutrombicula) belkini Gould
Trombicula (Eutrombicula) lipovskyana Wolfenbarger
Trombicula (Eutrombicula) splendens Ewing
Trombicula (Leptotrombidium) myotis Ewing
Trombicula (Neotrombicula) autumnalis (Shaw)
Trombicula (Neotrombicula) lipovskyi Brennan and Wharton
Trombicula (Neotrombicula) sylvilagi Brennan and Wharton
Trombicula (Neotrombicula) whartoni Ewing
Trombicula (Trombicula) crossleyi Loomis
Trombicula (Trombicula) fitchi Loomis
Trombicula (Trombicula) gurneyi Ewing
Trombicula (Trombicula) kansasensis Loomis
Trombicula (Trombicula) kardosi Loomis
Trombicula (Trombicula) merrihewi Loomis and Lipovsky
Trombicula (Trombicula) montanensis Brennan
Trombicula (Trombicula) ornata Loomis and Lipovsky
Trombicula (Trombicula) trisetica Loomis and Crossley
Walchia americana Ewing

EXTERNAL MORPHOLOGY OF THE TROMBICULID NYMPH

GROSS MORPHOLOGY

The generalized form and structure of trombiculid nymphs have been known since the pioneer work of the Japanese investigators. Hirst (1925:609) gives an excellent figure of the audit of *Trombicula autumnalis* and André (1930) gives a clear account of the morphology of that species. Other illustrations and descriptions of some postlarvae were published by various workers prior to and during World War II. Some of these contain inaccuracies since the figures were intended to present the generalized form of the animal rather than exact detail. In 1946 Wharton described the sclerotized anatomy of all stages of *Euschöngastia indica*, with attention to detail. Michener (1946a), Jenkins (1949a), Richards (1950), Wharton *et al.* (1951), Wolfenbarger (1952), Wharton and Fuller (1952), Womersley (1952), Brown (1952), Sasa (1953) and others have described morphological features of postlarvae.

The trombiculid nymph is an eight-legged form with a pair of chelicerae and a pair of palpi. Primary segmentation is obscured. The body may be divided into four general regions, the gnathosoma, the propodosoma, the metapodosoma, and the opisthosoma. The gnathosoma is the region bearing the mouth and mouth parts while the propodosoma bears the first two pairs of legs, the metapodosoma bears the second two pairs of legs, and the opisthosoma is the remaining posterior portion of the abdomen. In most trombiculids the propodosoma and metapodosoma are separated dorsally by a strong constriction, the body anterior to the constriction being called the proterosoma and that posterior to the constriction the hysterosoma. The gnathosoma is the most distinct region, and sometimes the entire body posterior to the gnathosoma is called the idiosoma.

The idiosoma has a single dorsal plate, the scutum or crista metopica, on its anterior dorsal portion. Ventrally, the area between the coxae of the first two pairs of legs is called the sternum. The genital opening and the anus are found on the venter between or behind the coxae of the last pair of legs. One or two pairs of eyes, when present, may be found on the anterior dorsal aspect of the idiosoma.

The four pairs of legs are borne in two groups, two pairs anteriorly and two posteriorly. The tarsi of all legs are provided with claws. All of the legs are used in walking, although the first pair of legs evidently functions as a sensory organ as well.

SETAE

Numerous and highly modified body setae characterize the group of prostigmatic mites to which trombiculids belong. Setae are also numerous and somewhat modified on the appendages. In the family Trombidiidae the forms of the body setae have been much used as generic and specific characters; but in the Trombiculidae, while these setae are not so strongly modified they are still useful as taxonomic characters. The specialized setae of the body and the scutum will be discussed in detail in other sections of this paper but the appendicular setae merit some special consideration.

In the classification of trombiculids based on larvae, the form and position of setae have been used as specific and as group characters. Wharton *et al.* (1951:13) standardized a system of terminology for the appendicular setae which has been widely accepted. The appendicular setae of larvae and postlarvae are essentially similar, so that some features of the terminology for larval setae

may be adapted for postlarvae. This scheme has not been followed invariably, since it seems preferable to propose a new term rather than to misapply the larval terminology.

The setae found on trombiculids fall readily into two classes: thick-walled branched and unbranched (nude) setae, and thin-walled nude setae. Thick-walled setae usually consist of a long stem with an attenuated tip and have few to many shorter branches which arise at more or less regular intervals, and often from several planes. Thin-walled setae are typically shorter, rather thickened, pointed or blunt at the tip, and are often transversely striated. Specializations of both types occur but the only point of confusion concerns thick-walled or "branched" setae which have no branches. Jones (1950:486) described in detail sectioned setae of the larva of *Trombicula autumnalis* and demonstrated that branched setae (both with and without branches) have thick walls while nude setae ("peg organs") have thin walls. Grandjean has called the thin-walled setae "solenidions." The thin-walled condition is evident under the phase-contrast microscope without special preparation, since an internal cavity can be seen in the basal portion of these setae; such a cavity is visible only in some of the larger branched setae and here the thick-walled condition is obvious. Thus in practice the separation of the two types usually presents no difficulties.

In postlarvae, thin-walled nude setae occur only on the appendages, these setae being increasingly numerous on the leg segments distal to the trochanter, and one such seta occurs on the palpal tarsus. All of the setae found on the body, including the nude setae on the hypostome, those on the genitalia, and the sensilla of the scutum, appear to be thick-walled setae derived from the branched type. The larval system for naming the thin-walled setae involves combining the name of the segment on which the seta occurs with the suffix "-ala." Thus, a thin-walled nude seta found on the tibia is called a "tibiala." For postlarvae, the terms basifemorala, telofemorala, genuala, tibiala, and tarsala may be used for these setae. Such terminology is used throughout this paper, the term "nude seta" referring only to thick-walled, unstriated setae that lack branches.

Many of the appendicular setae are set in pits, so that it is usually difficult to decide whether a circular structure surrounding the base of a seta is a pit or an alveolus. In the illustrations an alveolus is shown for each branched seta but is omitted from the thin-walled nude setae. This is probably the condition which obtains.

THE GNATHOSOMA

The gnathosoma is the most anterior and the smallest division of the body. It is completely fused to the propodosoma, with little trace of division ventrally and none dorsally. The gnathosoma consists of a somewhat conical basal portion (basis capituli) bearing the palpi dorsolaterally and the chelicerae dorsally, and a projecting distal portion (hypostome). These parts are discussed separately below.

The morphology of the gnathosoma of the adult of *Trombicula alfreddugèsi* has been well described by Brown (1952), and his descriptions appear to be generally applicable to both nymphs and adults of most species. Brown's work is a morphologic and not a taxonomic effort. His descriptions are difficult to apply in some instances to specimens mounted on slides in the usual manner. Thus discrepancies between Brown's presentation and that of the writer are partly due to differences in purpose and method of study.

Basis capituli. The exact extent of the basis capituli and its connection to the propodosoma are obscured by the process of clearing and mounting. The sclerotized structures mentioned by Brown (1952) may usually be located although no longer in normal position. Most of these sclerotized structures form a capsule (essentially the basis capituli) which is but rarely broken in mounting and is occasionally separated completely from the body. Apparently this capsule consists of the structures which Brown has termed epistome (E), epistomal apodemes (EAs), and apodeme at the junction of the basis capituli with the propodosoma (BCA). The hypostome is found at the distal end of this capsule, and occasionally the palpi remain completely articulated after mounting. The chelicerae are almost invariably displaced and the integumentary connections of the capsule with the body are either destroyed or obscured in mounting. The capsule (fig. 198) is roughly conical in shape, open at both ends and open dorsally, the two sides being connected dorsally by a single sclerotized crosspiece near the anterior end. The posterior margin, the dorsal margins, and the dorsal portions of the anterior margin are sclerotized. Apparently the dorsal portion behind the crosspiece is internal. The depressed space anterior to the crosspiece contains the chelicerae and the palpi are articulated dorsolaterally on the anterior margin. The hypostome projects from the anterior ventral portion.

The shape of the capsule in the species studied is approximately the same as that of *Trombicula trisetica* (fig. 198). The capsule is

somewhat broader and appears shortened in *Acomatacarus plumosus*, *Euschöngastia jonesi*, *E. pipistrelli*, species of *Euschöngastoides*, *Hannemania eltoni*, and species of *Pseudoschöngastia*; it is narrowed and somewhat elongated in *Speleocola tadaridae*.

The cheliceral apodemes (CA) and the skeletal structure forming lateral articulations for the chelicerae (ChA) appear to be firmly connected and usually remain so after mounting although no longer in position.

The pharynx is a broad, flattened tube which can be seen occasionally in the gnathosoma of mounted specimens. However it was not seen in all of the species examined. In certain species (*Euschöngastoides*, *Pseudoschöngastia*, and *Walchia americana*) the pharynx is quite distinct and is marked with a reticulate pattern (fig. 8). The significance of this marking is not known. In *Pseudoschöngastia hungerfordi* the pattern is restricted to the midline of the pharynx; in the other species the reticulations cover about half the width of the pharynx.

Hypostome. In mounted material the hypostome appears as a lobe projecting from the ventral part of the basis capituli; in unmounted specimens it appears coneshaped with the dorsum open. Mounting distorts the shape of the hypostome but it usually appears triangular and continuous with the venter of the basis capituli. The ventral portion bears setae; the dorsal portion bears a sclerotized hypostomal trough (Brown, 1952).

In most species the hypostome appears triangular and bears about eight nude setae, usually four on each side at the apex (fig. 9). Posterior to the nude setae are about ten to twenty branched setae, similar to those on the venter of the basis capituli. Usually it is impossible to delineate clearly the venter of the hypostome from that of the basis capituli, so that some setae cannot be assigned accurately to either. There is some intraspecific variation in the number of nude setae, occasional specimens having as many as ten or as few as six. These setae occasionally bear one or two fine branches. There are some marked and consistent variations from this typical condition; these merit further characterization.

In *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia americana* the hypostome is blunt, and occasionally the margin is slightly concave (fig. 8). Along the margin are about twenty short setae which are nude or have one or two branches. Behind these, some twelve longer branched setae are distributed over the venter of the hypostome. In *Walchia americana* the edge of the hypostome is

not as straight as in the other species; usually it is slightly convex.

Species of *Cheladonta* have the hypostome more elongated than do the typical species of the family and the apex bears eight to ten rather short nude setae (fig. 10). About ten nude setae are distributed over the remainder of the hypostome; occasional setae have one or two branches but there are no heavily branched setae on the hypostome.

Species of *Neoschöngastia* have a rather blunt hypostome which bears eight short nude setae on its apex (fig. 11); some ten branched setae are scattered over the more posterior portion. The apical nude setae are very short in *N. brennani* and somewhat longer in *N. americana*.

Acomatacarus plumosus and *Whartonia senase* have a blunt hypostome which bears six to eight apical setae, all of which have several branches. About twenty slightly expanded, branched setae are found on the remainder of the hypostome.

In *Chatia setosa* and species of *Hannemania* the branched setae covering most of the hypostome are quite numerous. Some of the specimens of *Hannemania eltoni* have as many as fifty such setae.

Chelicerae. The chelicerae are composed of two segments; a proximal elongated base and a distal blade. The base is articulated to the basis capituli and has a slight amount of forward-backward movement. The blade is articulated with the base at the sides to allow for dorsal-ventral movement. The chelicerae have no setae.

In mounting, chelicerae usually become partially detached and are seen in side view. This position seems to be favorable for characterizing the base and it is certainly the best position for observation of the blade. All of the drawings of the chelicerae are made from the medial (inner) surface, and all measurements are made in side view.

The base is typically elongated, roughly oval in cross section, pointed posteriorly, blunt anteriorly, with a straight ventral margin and an arched dorsal margin. The area of articulation with the gnathosoma is on the posterior ventral portion and occupies about one half of the length of the ventral portion, extending from the posterior tip forward (see figures). In mounted material the area of articulation is seen to be more on the medial surface than directly ventral (see also Brown, 1952, p. 47, fig. 4; p. 49, fig. 8). The base is unusually elongated in *Blankaartia*, *Cheladonta*, *Speleocola tadaridae*, *Trombicula ornata*, and *T. kansasensis*; the area of

articulation is also elongated in *S. tadaridae*, *T. kansasensis*, and *T. ornata*. The articulating area appears to extend across the posterior part of the base instead of the ventral surface in *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia americana* (figs. 30-33, 35). The area of articulation appears shortened in *Neoschöngastia* and *Whartonia senase*. Otherwise, characterization of the shape of the base is difficult, since individual variation, although slight, is noticeable. In some species the base appears to have a more robust shape, *i. e.*, shorter and broader, than in others. However, different specimens of the same species present slightly different aspects and intermediate conditions defy grouping. Aside from the obvious deviations given above, the shapes of the cheliceral bases are more or less similar.

Punctuation is generally present on the cheliceral base, and appears to be more dense on the dorsal and perhaps the ventral portions than on the lateral portions. Puncta are difficult to see in poorly mounted specimens and even under good conditions estimates of size and number of the puncta are difficult. Occasional specimens and some species of specimens appear to lack puncta altogether, and specimens preserved soon after they enter the nymphal stage may lack them. Species which have punctuation of the cheliceral bases sparse or absent include *Cheladonta ouachitensis*, *Euschöngastia criceticola*, *E. cynomyicola*, *E. pipistrelli*, *Euschöngastoides loomisi*, *Pseudoschöngastia farneri*, *P. hungerfordi*, *Trombicula crossleyi*, *T. gurneyi*, and *T. ornata*. Puncta are particularly numerous on the cheliceral bases of *Euschöngastia diversa*, *E. jonesi*, *E. peromysci*, *E. trigenuala*, and *Hannemanina dunni*. Conspicuously coarse punctuation is present on the bases of *Hannemanina dunni*, *Leeuwenhoekia americana*, *Trombicula sylvilagi*, and *T. whartoni*.

The cheliceral blade usually bears a resemblance to a single blade of a pair of shears, so the term "shearlike" has been used in the section on taxonomy to designate this usual condition. The blade is flattened laterally, with an attenuate tip ending in a sharp point and a row of teeth on the dorsal edge. The blade appears to be adapted for piercing rather than for cutting. The proximal portion of the blade is an upright structure, the apodeme of the blade, lying partly within the cheliceral base. The blade articulates with the base at two points, one on each side of the apodeme of the blade. Apparently muscles attach here also. This apodeme is slightly constricted in most species. The constriction is particu-

larly noticeable in species of *Cheladonta*, *Euschöngastia trigenuala*, *Trombicula kansasensis*, and *T. ornata*. No constriction was seen in *Acomatacarus*, *Chatia setosa*, *Euschöngastoides*, *Hannemanina*, *Trombicula myotis*, and *Whartonia senase*.

The distal portion of the blade in most species curves upward to an acuminate apex. The blades of some species appear to be broader than others; but as with the shape of the cheliceral base, this character proved very difficult to use. Particularly broad, *i. e.*, deeper and coming to a more abrupt point, are the blades of *Euschöngastia criceticola*, *E. diversa*, *E. Peromysci*, *E. trigenuala*, *Trombicula lipovskyi*, and *T. sylvilagi*. Related species approach this condition to such an extent that the characterization is somewhat arbitrary (see illustrations). The few following types are sufficiently distinct from the usual blade type to merit description: *Whartonia senase* and *Neoschöngastia* spp. have a considerably narrowed blade which curves up at the tip; the blade of *Acomatacarus arizonensis* is also narrowed but is straight at the tip, being dagger-like; in species of *Cheladonta*, the blade is broad but also strongly curved. Elongations of the usual shape also occur; but these are difficult to single out. However, species of *Blankaartia* seem to show the greatest elongation.

A dorsal row of teeth on the cheliceral blade was found in all species except *Neoschöngastia brennani*, which lacks teeth altogether. It is possible that the two specimens of *N. brennani* are anomalous in this respect. Occasional specimens of other species were found to lack teeth on one of the blades or to have the number greatly reduced. Often, but not always, it appeared that these specimens had been preserved soon after emergence.

Cheliceral teeth vary in size and number among species, within the species, and on the individual specimen. Customarily the largest teeth are found near the base of the blade and become progressively smaller towards the tip, where they are tiny. This is not a regular gradation, however; very tiny teeth frequently occur at the base of the blade, and the row of teeth is usually uneven, with teeth of various sizes occurring together. Some of the configurations suggest that a large tooth may break off, leaving several small points. The irregularity, together with the small size, makes cheliceral teeth difficult to count and somewhat difficult to characterize for a given species. In most instances there is a relationship between the size and the number of teeth, species with larger teeth having the smaller number, if such factors as the size of the mite

or peculiar modifications do not disturb the comparison. This relationship is less noticeable in variation within the species; individuals with different numbers usually have teeth of similar size. Counts of teeth were attempted for all species and these figures are given in the descriptions as approximations. The character of many small versus few large teeth has some value in separating some of the species, but cannot be rigidly applied due to the inaccuracies resulting from difficulty in counting. As noted above, occasional specimens have a blade with the teeth greatly reduced or absent.

Teeth are particularly numerous on the chelicerae of *Chatia setosa*, *Euschöngastia pipistrelli*, and *E. setosa*. Large teeth, reduced in number, are found in *Cheladonta micheneri*, *Pseudoschöngastia farneri*, and *Trombicula sylvilagi*. These two groupings include extreme cases; other species show tendencies toward these extremes. Species of *Cheladonta*, *Euschöngastoides loomisi*, *Whartonia senase*, and to some extent *E. hoplai*, show a restriction of the teeth to the distal portion of the blade. The row of teeth (the dorsal margin of the blade) is straight rather than curved upwards in *Acomatacarus plumosus*, *Euschöngastoides*, *Hannemania multifemorala*, and *Whartonia senase*; however, other species approach this condition.

A membranous structure, the pseudochela, is usually visible as a projection from the dorsal margin of the end of the cheliceral base. This structure has been omitted from some of the illustrations but it is believed to be present in all species although sometimes difficult to see. Possibly it is a remnant of the fixed chela, or simply an extension of the articulating membrane of the base-blade union. The shape is variable, probably being influenced by mounting techniques.

The cheliceral apodemes are visible in most specimens and are generally similar in shape. Specific differences may exist in the shape of the structure but if so they are masked by individual variation. These structures are also frequently distorted during the mounting process. They have not been figured for most species.

Measurements of chelicerae. Since the chelicerae usually fall into side view during the mounting process, and are rarely distorted by mounting, they were considered to be suitable subjects for measurement. It was hoped that a measurement could be found which would serve as an index of total body size, since this is not suitable for accurate measurement due to distortion of the body in

mounting. Three measurements were made on the chelicerae, as follows: BL: Length of the cheliceral base, measured from the posterior extremity to the point of articulation of the blade on the medial surface. BH: Height of the cheliceral base, measured at the widest point. CL: Length of the cheliceral blade, measured from the tip to the back of the apodeme of the blade.

Most of the samples of nymphs are small. Large samples (more than thirty individuals) with identical data were available for *Trombicula lipovskyi* and *T. montanensis*. Graphic checks for normality showed that the three measurements were skewed to the right in *T. lipovskyi* (an abundance of larger values and a shortage of smaller ones); in *T. montanensis* they were normally distributed or nearly so. Two ratios were made from the values, these being BL/BH and BL/CL; these ratios were checked by graphic methods and found to be normally distributed in both species.

It should be emphasized that these measurements were taken in an endeavor to discover taxonomic characters. It is to be expected that two species could differ in a measurement but it is not particularly surprising when they do not; also, the figures given are based on individuals which in some cases are probably members of different populations of the species. This work is intended to show that measurements of the chelicerae are practical for taxonomic purposes, including investigations of variation within a species; that these measurements in some cases may serve as characters for the identification of species; and that the ratios used have a value similar to that of the measurements on which they are based. The measurements are used, however, only to separate species or groups of species from one another where such separation is clear. The ratios serve particularly to quantify relationships which are already obvious.

Means of the three measurements and their ratios, with their standard errors, are given in the species descriptions in the taxonomic portion of this paper. Examination of these will show that some of the species may be separated by cheliceral measurements even though some accuracy is lost because of skewness. Also, the measurements seem to give an indication of the general size of the mite. Within a species group where cheliceral shapes are similar, these measurements more accurately indicate relative size.

The ratios based on these measurements are not valuable in separating closely related species from one another. However, several interesting groupings of species appear, as shown in Tables 1 and 2. These ratios give a quantitative expression to some pe-

cularities evident in the illustrations, as far as the extreme forms are concerned. That related species have similar ratios may be seen in the Tables.

The ratio BL/BH ranges from about 1.8 to about 4.0. Most of the species have a mean ratio between 2.3 and 3.0; the larger mean ratios of *Speleocola tadaridae* (3.5), *Trombicula ornata* (3.6), and species of *Cheladonta* (4.0) are distinctive. There is also a group of species with mean ratios between 1.8 and 2.1; this group is not so distinctly separated from the majority but is worthy of mention. The group includes *Acomatacarus arizonensis*, *A. plumosus*, and *Whartonia senase* (1.8); *Leeuwenhoekia americana* and *Pseudoschöngastia farneri* (1.9); *P. hungerfordi*, *Euschöngastoides hoplai*, and *Walchia americana* (2.0); and *E. loomisi* and *Hannemanina multifemorala* (2.1).

The ratio BL/CL ranges from about 1.6 to about 3.7. The only species clearly separated from the rest are members of the genus *Cheladonta* (3.6 and 3.7).

Palpi. The palpi are the second pair of appendages of the gnathosoma; they are attached anteriorly at the sides of the basis capituli and project forward in front of the hypostome. The palpi are arched dorsally, so that the anterior ends point downwards. The segments are hinged on their dorsal margins. Brown (1952: 43) states that none of the muscles of the palpi are extensors. Five free segments are recognizable in the palpus, these being trochanter, femur, genu, tibia, and tarsus. The coxae are incorporated into the basis capituli and are not apparent as segments. The palpus has a chelate apex ("thumb-claw process" of authors); this consists of a "thumb," the palpal tarsus, which articulates near the base of the tibia instead of at the apex, and a claw arising from the apex of the tibia. The chelate apex of the palpus is characteristic of several families of prostigmatic mites.

The most favorable position for observation of the palpi is a side view, so that the medial (inner) and lateral (outer) surfaces are prominently displayed, and the dorsal and ventral surfaces form the margins. The palpi usually fall into this position in mounting.

In general, palpi of the different species have relatively similar aspects. Some appear more elongated than others but a gradation occurs. The short, broadened palpi of *Neoschöngastia* appear to be distinctive in shape but others (*Pseudoschöngastia*) approach this condition. General palpal shape within a species is sufficiently

TABLE 1. The Ratio BL/BH (Cheliceral measurements): Distribution of Species among Taxonomic Categories.

MEAN RATIO	Leeuwenhoekinae	<i>Eutrombicula</i>	<i>Neotrombicula</i>	other <i>Trombicula</i>	<i>Euschönngastia</i>	remaining <i>Trombiculinae</i>
1.8	3					
1.9	1					1
2.0						3
2.1	1					1
2.2						
2.3	2	2	1			
2.4	1		1		4	
2.5		2	1		1	2
2.6			1	1	2	
2.7				1	1	
2.8				1		2
2.9				4		
3.0				1		1
3.5						1 (<i>Speleocola</i>)
3.6				1 (<i>T. ornata</i>)		
4.0						2 (<i>Cheladonta</i> spp.)

TABLE 2.—The Ratio BL/CL (Cheliceral measurements): Distribution of Species among Taxonomic Categories.

MEAN RATIO	Leeuwenhoekinae	<i>Eutrombicula</i>	<i>Neotrombicula</i>	other <i>Trombicula</i>	<i>Euschönngastia</i>	remaining <i>Trombiculinae</i>
1.6	4		1			1
1.7	1	2	1			
1.8	2	1	2		1	1
1.9	1	1		2	4	1
2.0				3	1	3
2.1					2	2
2.2				1		
2.3				2		
2.4						1
2.5						1
2.6						1
2.7						
2.8				1 (<i>T. ornata</i>)		
3.0						
3.6						1 (<i>Cheladonta micheneri</i>)
3.7						1 (<i>C. ouachitensis</i>)

constant, however, that some species may be classified as having palpi "elongated" or "shortened." These terms are subjective and a more valuable characterization of the palpus requires a more detailed discussion.

Certain features of the palpal setae require special consideration. Except for specialized setae on the tarsus, palpal setae may be of two types: unipectinate and bi- or multipectinate. Unipectinate setae are straight setae with branches arising from one side only. The branches are thick basally, taper abruptly, and run parallel to the body of the seta. Other setae are flexible; the branches taper gradually, run in different directions, and arise from more than one side of the seta. These flexible setae appear to be primarily bipectinate with occasional branches slightly out of line. Often in mounting, however, flow of the medium causes all of the branches to point in the same direction; also, the setae may become twisted, so that the exact nature of the branching may be obscured.

On the genu, unipectinate setae are found on the dorsal margin and bipectinate setae on the ventral margin, with intermediate conditions on the lateral portions. The intermediates are more stiff than the ventral setae and are occasionally unipectinate.

Setae on the femur are similar to those of the genu, except that the dorsal setae are usually bipectinate and differ from the ventral setae only in being more stiff, although not as straight as the dorsal genual setae.

The trochanter is a small, somewhat triangular segment. This shape is fairly constant within species, and most of the species have similar trochanters. Species of *Cheladonta* are characterized by a noticeable elongation of the trochanter (fig. 85). *Whartonia senae* (fig. 60) and *Acomatacarus plumosus* (fig. 88) have short broad trochanters, otherwise no distinction among species was noted. There are no setae on the trochanter. The articulation between trochanter and femur does not appear to be flexible.

The femur is the longest palpal segment. The shape of the femur is similar in all species. It is narrowed at the proximal end and broadened at the distal end. In *Neoschöngastia* (figs. 71-72) the femur is extremely broadened. It is slightly arched and the apparent shape varies somewhat with the position of the palpus on the slide. A number of setae are borne on the femur and taxonomic characters were found in the number and nature of these setae. In general, the dorsal setae are thicker and stiffer than the ventral ones. Elongated setae are often found on the

lateral and medial portions of the femur. Setae with reduced branching and occasional nude setae were noted in *Blankaartia* and in *Speleocola tadaridae* (fig. 86). *Leeuwenhoekia americana* has distinctive dorsal femoral setae. In *Acomatacarus arizonensis*, *A. plumosus*, and *Whartonia senase* some of the femoral setae are expanded (fig. 88). The dorsal femoral setae of *Trombicula* (*Eutrombicula*) *belkini* (fig. 79) have many more branches than do those of other members of that subgenus.

The mean number of femoral setae for each species is given in the descriptions of species. To obtain this figure the setae were counted on both femora and an average number obtained for each specimen. The means given are based on these average values. Occasionally one femur is obscured to the extent that the setae cannot be counted but usually, at least one femur is clearly visible on each specimen. The number of setae on the femur is a characteristic which may be used in separation of species. Usually, related species have about the same number of femoral setae but the exceptional cases provide taxonomic characters. Also, members of the subfamily Leeuwenhoekiiinae have a greater mean number of femoral setae than do the species in Trombiculinae (see Table 3). No other categories are clearly separated.

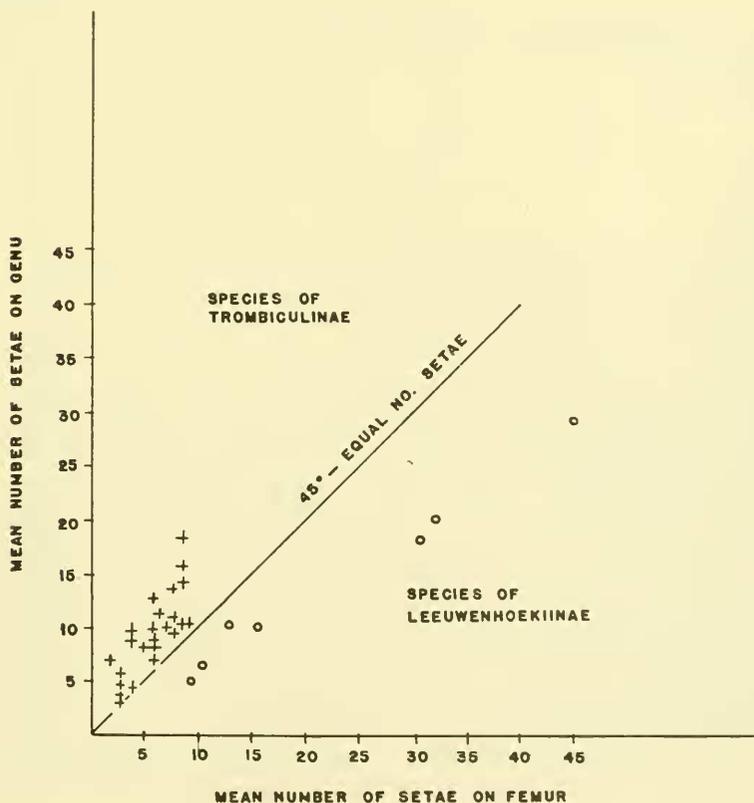
It seems reasonable that the number of setae on a segment could be correlated with size. Unfortunately measurements of palpal segments are difficult to take accurately, due to distortion in mounting, different angles of view, and lack of definite points from which to measure. Body size also cannot be accurately measured on mounted specimens. Therefore the length of the cheliceral base was used as an index of size; the validity of this assumption is admittedly open to question. The association between the number of femoral setae and the length of the cheliceral base was tested by Olmstead and Tukey's (1947) Corner Test for Association. Within the species, the two were found to vary independently in most cases. When the mean values for all of the species were used, however, association was significant. Species with longer cheliceral bases tend to have more femoral setae. It is inferred that larger species have more femoral setae. That these two vary independently within the species is also of interest.

The palpal genu is similar in shape in most of the species; it is cylindrical, slightly smaller at the distal end, and about as long or slightly longer than broad. The genu is wider than long in species of *Cheladonta*, *Pseudoschöngastia*, and *Walchia americana*.

Some of the genual setae are expanded in *Acomatacarus arizonensis*, *A. plumosus*, and *Whartonia senase*. Certain of the genual setae are distinctive in *Leeuwenhoekia americana*. Dorsal genual setae are occasionally nude in *Speleocola tadaridae*, *Trombicula crossleyi*, *T. fitchi*, *T. kardosi*, *T. merrihewi*, *T. montanensis*, *T. ornata*, and *T. trisetica*.

The number of setae on the genu was handled like that of the femur, and means and standard errors are given in the descriptions of species. No species groups are indicated by these figures but, when considered with the mean number of femoral setae, an interesting relationship emerges. The Leeuwenhoekinae have a greater mean number of setae on the femur than on the genu, while the trombiculines have either a greater number on the genu than

GRAPH 1: SETAE ON PALPAL FEMUR AND GENU



on the femur or about the same number on the two segments (see Graph 1). This character holds fairly well on individual specimens; of the trombiculines only four individuals were found which had a greater number of setae on the femur, and in these cases the difference was one seta. The Leeuwenhoekinae, as individuals, have at least four more setae on the femur than on the genu.

As with the femoral setae, the number of genual setae was tested for association with the length of the cheliceral base. Again,

TABLE 3.—Mean Number of Setae on Palpal Femur: Distribution of Species among Taxonomic Categories.

MEAN NUMBER SETAE	Leeuwenhoekinae	<i>Eutrombicula</i>	<i>Neotrombicula</i>	other <i>Trombicula</i>	<i>Euschöngastia</i>	remaining <i>Trombiculinae</i>
3				5		3
4			2	2	3	4
5		1	1	1	2	2
6		1	1	1		1
7		2				1
8					2	1
9					1	
10	3					
15	1					
20						
25						
30	2					
45	1					

within the species the two were found to vary independently but between species, using average values, a positive association was present (see Graph 2).

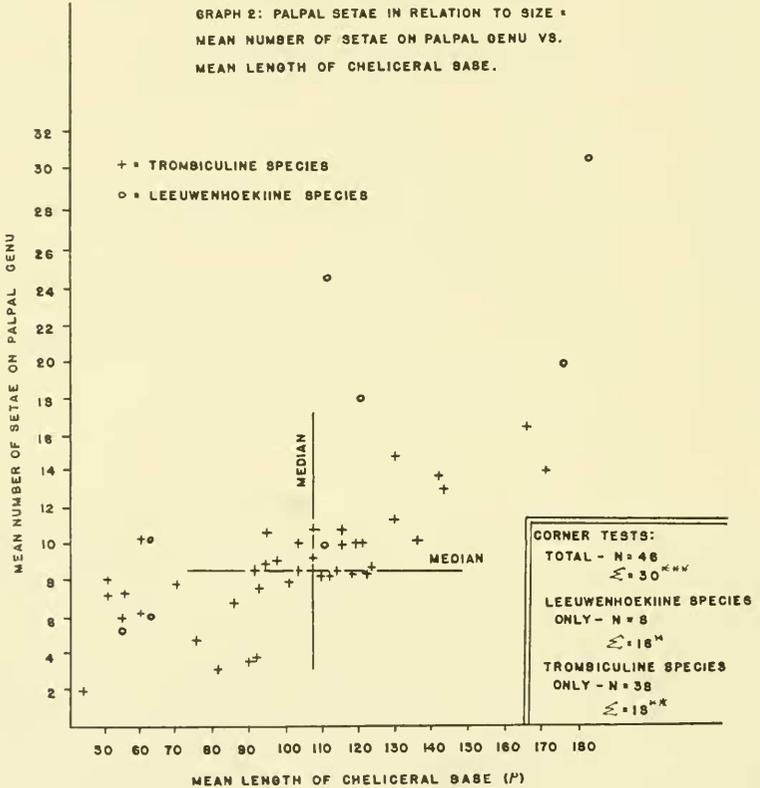
The palpal tibia is a small segment with a distal elongation bearing the palpal claw and the accessory claws. The palpal tarsus articulates to the ventral margin of the tibia. The distal elongation is extreme in *Blankaartia* (figs. 169-172) and is sufficient for identification of that genus. The palpal claw is slightly curved, never divided as in the larvae, and usually about the length of the outer tibial margin. Claws are difficult to compare as to shape, since on the slide a slightly turned claw presents a different aspect. Within a series of specimens gradations from an abruptly tapered claw to an attenuated claw may be seen. The claw appears to be con-

TABLE 4. Mean Number of Setae on Palpal Genu: Distribution of Species among Taxonomic Categories.

MEAN NUMBER SETAE	<i>Leeuwenhoekinae</i>	<i>Eutrombicula</i>	<i>Neotrombicula</i>	other <i>Trombicula</i>	<i>Euschöngastia</i>	remaining <i>Trombiculinae</i>
3				2		2
4						1
5				2		
6	1					1
7	1		1			2
8			2	3		4
9				1	3	
10	1		1	1	3	2
11	1	2				
12					1	
13		1				1
14		1				
15						
16					1 (<i>pipistrelli</i>)	
17						1 (<i>Blankaartia velascoi</i>)
18	1					
20	1					
25	1					
31	1					

cal or nearly so, and is always pointed. The claws of *Neoschöngastia* (figs. 100-101, 193-194) are considerably elongated, being more than twice the length of the outer tibial margin. In *Blankaartia* the claws are shorter than the tibia, which is elongated. The accessory claws are at the base of the palpal claw, on or near the dorsal margin and they project medially and forward. The tips of the accessory claws are spatulate; when seen in side view they appear to be sharply pointed but are actually blunt. Most of the species have two accessory claws in tandem, *i. e.*, one behind the other. In *Blankaartia* the number is variable, ranging from two to seven, and the accessory claws are not all in tandem. In *Neoschöngastia americana* the lower accessory claw is absent and a nude or branched seta is present in the same position. In *Neoschöngastia brennani* the lower accessory claw is decidedly smaller than the upper one. Otherwise the two accessory claws appear to be about the same size and length though often they are not parallel and are difficult to compare.

Both the claw and the accessory claws are probably modified setae. There seems to be a gradient of stiffening setae on the dorsum of the palpus which involves the straight femoral setae, the monopectinate setae of the genu and tibia, the accessory claws, and the claw. One specimen of *Speleocola tadaridae* had a branched seta in place of the claw; the substitution of a seta for an accessory claw in *Neoschöngastia americana* has been mentioned.



The medial (inner) surface of the tibia usually bears one branched seta adjacent to the articulation with the palpal tarsus. This seta is lacking altogether in species of *Neoschöngastia* and *Hannemania*. In *Blankaartia alleei*, *Speleocola tadaridae*, *Trombicula crossleyi*, *T. merrihewi*, and *T. trisetica* the seta is often nude. In other species the seta is occasionally duplicated or deleted. Additional setae on the medial surface are regularly found in *Neoschöngastia americana*, where a seta is substituted for the

lower accessory claw, *Chatia setosa*, which has one to three additional setae, and species of *Hannemania*, which have an additional seta below the accessory claws. This latter seta is very stiff and unipectinate with fine branches. Setae on the dorsal margin of the tibia have been counted with those of the lateral surface, although occasionally one appears to be on the medial surface.

Several setae, usually four or five, are present on the lateral (outer) surface of the tibia; these include an apical unbranched seta, stiff unipectinate dorsal setae, and flexible ventral setae. Usually the separation between types of dorsal and ventral setae is not so distinct as on the genu. The apical nude seta is invariably present and rarely with one or two fine branches.

The palpal tarsus is attached to the ventral margin of the tibia; it forms the "thumb" of the chelate apex. The tarsi of the different species have much the same shapes; a narrow, tapered segment, rounded on the end. The tarsus is subject to a large amount of individual variation in shape, to which the mounting process probably contributes. The shape of the tarsus is not sufficiently reliable to characterize the species investigated. The tarsal setae, however, provide several characters.

Typically the tarsus has about nine branched setae, about five apical nude setae, and a striated tarsala. In those species with nine branched setae, the branched setae are remarkably constant in arrangement. On the dorsal margin is a row of three branched setae decreasing in size distally. These setae are strongly unipectinate, with thick shafts and fine branches. The other branched setae have thinner shafts, fewer branches, and are less obviously unipectinate or bipectinate. These are fairly constant in position; two are found on the lateral surface, two on the medial surface, and two on the ventral margin. In the drawings six of the branched setae are included on the lateral surface and three on the medial surface for purposes of comparison. Often it is not possible to tell to which surface the dorsal or ventral setae might belong. Variations in the number of branched setae on the tarsus are frequent since there may be additional setae on the lateral surface or lack of lateral or medial setae. Species of *Hannemania* and *Chatia setosa* have up to eighteen branched setae. *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia americana* have five to seven branched setae on the tarsus. Species of *Neoschöngastia* and *Speleocola tadaridae* have tarsal setae nude or with reduced branching. In *Neoschöngastia* such setae are short and stout.

The tarsala is located on the lateral surface of the tarsus and is probably invariably present. The position of this seta varies within the species from near the base of the tarsus to about the midpoint.

Several short nude setae are present on the tip of the tarsus. These are modified branched setae of the thick-walled type and rarely, tiny branches may be seen. The number and arrangement of these apical nude setae are sufficiently constant for characterization of some species. It is usually possible to refer these setae either to the inner or the outer surface. Those species with five apical nude setae usually have three inner and two outer. Deviations from five apical nude setae were found as follows. Six apical nude setae (four inner, two outer): *Leeuwenhoekia americana*. Four apical nude setae (three inner, one outer): *Euschöngastia criceticola*, *E. cynomyicola*, *E. diversa*, *E. peromysci*, *E. pipistrelli*, *Trombicula montanensis*, and *T. myotis*. Three apical nude setae (two inner, one outer): *Acomatacarus plumosus*, *Speleocola tadaridae*, *Trombicula crossleyi*, *T. merrihewi*, *T. ornata*, and *T. trisetica*. Two apical nude setae (one inner, one outer): species of *Euschöngastoides*, and *Pseudoschöngastia*. One apical nude seta: outer surface, species of *Neoschöngastia*; inner surface, species of *Cheladonta* and *Walehia americana*. Species of *Hannemania* have five apical nude setae arranged four inner, one outer. *Blankaartia alleei* has four apical nude setae, these being two inner and two outer.

Occasional specimens possess one apical nude seta more or less than other members of the species. This variation was noted in *Trombicula whartoni* (five or six setae), *Euschöngastia jonesi* and *E. setosa* (four or five setae), and *Chatia setosa* (six or seven setae).

THE SCUTUM

The scutum of trombiculid mites is a simple plate in the larvae, but in the nymphs and adults it is highly modified. The scutum is probably the most frequently illustrated feature of postlarvae and early descriptions of trombiculids are devoted largely to this structure. The scutum bears the sensilla or pseudostigmatic setae. The exact function of these setae is unknown but they appear to be primarily tactile organs. The modification of the scutum itself, especially the sensillary area, suggests that it has a particular function, however, a thorough study of this structure has never been made.

Usually the scutum is considered to consist of three regions: An anterior tectum, a rodlike crista, and a posterior sensillary area. The tectum is a membranous flap extending from the anterior end of the

crista above the gnathosoma and usually bearing one or two setae. The crista is a heavily sclerotized rod lying on the surface of the integument. Posteriorly, the crista expands into the sensillary area. The sensillary area is a complicated structure, apparently hollow internally, usually strengthened with ridges, and bearing the sensilla at its sides. In the mounting process, the shape of the scutum is usually somewhat distorted, particularly the sensillary area becomes crushed. Also, the scutum but rarely turns on its side, so that a dorsoventral view is most commonly seen. The exact nature of the sensillary area is difficult to make out in this view, but for purposes of taxonomy this position is preferable.

The combination of mounting distortion and dorsoventral expansion of the sensillary area increases the amount of variability seen among mounted specimens. The general aspect of the sensillary area among a series of similar specimens is often quite variable, so that characterization of the scutum for a given species may be difficult. Some previous attempts at separation of similar post-larvae on scutal characters have failed due to this variability. When a characterization is built upon a series of specimens some of the features are found to be relatively constant, but these features must be used with caution. An effort was made to use typical specimens for illustrations, but to handle adequately the variation within a species would require in some cases a drawing for every specimen. In spite of this variation, some features are sufficiently constant as to permit characterization of species and species groups.

The scutum is a relatively simple structure in the leeuwenhoekiiine species but becomes more complicated in the trombiculines. The description of this structure may be handled profitably by beginning with the simple types and noting the changes that occur in the more complicated types. This is not intended to be a phyletic sequence except in the most general sense. The elements of phylogeny are certainly involved but the series of examples is not necessarily in the proper order.

The scutum in the Leeuwenhoekiiinae (figs. 138-143). These species have scuta which appear intermediate in morphology between the trombiculiine species and species of the family Trombidiidae, particularly the subfamily Microtrombidiinae. They differ from the latter in having two tectal setae rather than six or more.

The tectum of the Leeuwenhoekiiinae is rather well sclerotized; the margin of the tectum is smooth and never bears serrations or teeth. The tectum is small in species of *Hannemania*, intermediate in species of *Acomatacarus*, and large in *Chatia setosa*, *Leeuwen-*

hoekia americana, and *Whartonia senase*. In the latter three species the margins of the tectum are heavily sclerotized and the shape of the tectum is somewhat sagittate. In species of Trombidiidae which have such a sagittate, projecting tectum, the term "nose" has been applied to the structure. The tectum bears a pair of setae, usually in the midregion but apically in *Hannemania* and *Acomatacarus*. These setae are not always side by side and seemingly their position may be disturbed by the mounting process. On the single specimen of *Whartonia senase* these setae are almost in tandem. The tectal setae bear short branches and differ from the body setae if the latter are modified. In *Acomatacarus plumosus* (fig. 138) the tectal setae resemble the body setae, being somewhat expanded. In *A. arizonensis* (fig. 142) the tectal setae are not expanded although the body setae are. The tectal setae of *Whartonia senase* (fig. 143) are forked while in *Leeuwenhoekia americana* (fig. 140) they are unusually elongated. The tectal setae are set in pits which may have sclerotized margins. These are particularly evident in *Hannemania dunni*.

The crista is a thin rod with somewhat irregular margins and is readily subject to distortion in mounting. The connection of the crista with the tectum is not always visible. It may be but lightly sclerotized and is sometimes obscured by body setae. The crista is rather broad in *Acomatacarus arizonensis* and *Chatia setosa*. Some punctations may be visible on the crista and are prominent in *Chatia setosa* (fig. 141). The crista appears to be on the surface of the integument, since integumental striations never run over it. Actually the crista may lie in a depressed area; at least that of *Chatia setosa* gives this impression.

Beneath the sensillary area is a continuation of the crista, the basal plate. In the leeuwenhoekiiines this plate may be identified as two sclerotized bands, continuous with the crista anteriorly and uniting posteriorly to form a ventral apodeme, which projects behind the sensillary area proper and is mostly subintegumental. The posterior limits of the apodeme are sometimes hard to find. In the illustrations the basal plate is indicated by dotted lines on one side of the sensillary area. The sensillary area is usually wider than the basal plate, but nearly coincides with it in *Acomatacarus arizonensis*, *Chatia setosa*, and *Leeuwenhoekia americana*. The space between the two bands of the basal plate lies beneath the center of the sensillary area and is oval in *Acomatacarus arizonensis*, and circular to triangular in other species.

The sensillary area proper is on the surface of the integument and is continuous with the crista anteriorly. The center of the sensillary area is a continuous plate which is usually broken in mounting. It may be normally extended dorsally to form a dome-shaped structure which is continuous with the body cavity through the opening in the basal plate. The breaks which are seen on almost all specimens, and which presumably occur during the mounting process, are never regular and vary from specimen to specimen. However, some species show a rather constant structure which may indicate lines of weakness or actual sutures. In *Hanne-
mania eltoni*, an inverted triangle with ridges as borders is seen on most specimens (fig. 139). Whatever the nature of the central part of the sensillary area, the individual variation appears to rule out taxonomic characters.

The shape of the sensillary area is roughly circular except in *Acomatacarus arizonensis*, which has a transverse oval sensillary area. The area is bordered by ridges posteriorly and at the sides; these are irregular in most specimens and are probably also distorted in mounting.

The sensillary bases or pseudostigmata are found at the sides of the sensillary area to midway between the sides and the middle of the area (*Acomatacarus arizonensis*, *Chatia setosa*). These appear to be conical pits. Around the base of the sensillum itself is a heavily sclerotized ring, and at the outer margin of the pit is a similar larger ring. Between these two are several less distinct concentric circles. Jones (1950:487) has described the sensillum and sensillary bases of the larva of *Trombicula autumnalis*. Their structure is similar to that of the nymphs and suggests their function to be "a sensory perception of touch and probably of vibrations in the air."

The sensilla in the Leeuwenhoekiinae are flagelliform and unbranched. There appear to be no tiny basal branches. The length of the sensilla is not readily measured because the structures are rarely sufficiently straight and because their very fine tips disappear among the body setae. No characters associated with the sensilla were found among species of Leeuwenhoekiinae.

A possible character mentioned by Audy (1954:131) involves "parascutal" setae. These are the body setae which are found at the sides of the crista in front of the sensillary area. Since these setae merge with the other body setae behind the sensillary area, it is not possible to enumerate them accurately in the Leeuwen-

hoekiinae. In *Hannemania* there are about fifty such setae, and in smaller species (*Acomatacarus arizonensis*) about ten or fifteen. These setae are morphologically similar to other body setae, the most anterior of them being slightly smaller. In the illustrations, setal bases beside the crista are indicated and one body seta is figured. Other setae occur lateral to these in the prescutal area.

Puncta are seen occasionally in the sensillary area. They are found in the anterior area in *Chatia setosa* and *Leeuwenhoekia americana* and scattered over the sensillary area in *Hannemania*; other species may show scattered puncta on some specimens.

The scutum in the Trombiculinae (figs. 138-168, 173, 180). In general, scuta of trombiculines differ from those of leeuwenhoekiiines in having one or no tectal setae instead of two, in having lateral keels along the crista (in most cases), in having branches on the sensilla (usually), and in having a sensillary area which is structurally more complicated.

Modifications of the scutum in the trombiculine genera allow three types of scuta to be recognized. These are discussed separately below. These types tend to grade into one another but the division is of use in the discussion.

"Type A" is possessed by *Euschöngastoides hoplai*, *E. loomisi*, *Pseudoschöngastia farneri*, *P. hungerfordi*, and *Walchia americana* (figs. 144-147). These species have a scutum with a rather short crista and a broad sensillary area which is less complicated than the following two types.

The tectum is broad and short in all but *Walchia americana*, which has an almost square tectum. Species of *Pseudoschöngastia* lack serrations on the tectum. Small serrations are present on the anterior border of the tectum in species of *Euschöngastoides*, and large, long serrations are found on the tectum of *Walchia americana*. The tectal seta is lacking in *Walchia americana* and is very short in the other species. Branching is much reduced in all except *Euschöngastoides hoplai*. The connection of the crista with the tectum, and the posterior portions and corners of the tectum, are difficult to see in these species, except for *Walchia americana*.

The crista is a rather narrow, heavily sclerotized rod. Lateral keels (Brown, 1952:20) appear to be present in all species. These are flaplike, membranous structures lying beside the crista; they are invariably displaced during the mounting process so that their exact position is not known. Apparently they parallel the crista on

each side and connect posteriorly with the sides of the bulla (see below). Lateral keels were not visible in all specimens, and usually only portions of them could be seen. They are most clearly visible in *Walchia americana*.

The crista joins the sensillary area and immediately divides into two arms which run laterally at right angles to the crista. These form the anterior margin of the basal plate. Among scuta of this type the basal plate consists of two halves lying approximately under the sensillary bases. In *Euschöngastoides* the plates also appear to have a thin posterior connection. The basal plate contains openings for the sensillary bases. The shape of the basal plate is slightly different among the three genera, the anterior parts being somewhat difficult to see. At the anterior portion of the sensillary area a somewhat triangular structure occurs, which has its apex on the posterior part of the crista and its base in the middle of the sensillary area. The term "bulla" seems appropriate for this structure, since it seems to be hollow and domelike, and expanded dorsally. The bulla is continuous with the crista anteriorly; small ridges or bars connect the corners to the sides of the sensillary area; and the lateral keels appear to be attached at these corners. The posterior margin is convex and is usually irregular. The sensillary bases are similar to those of the leeuwenhoekiiine species; they are located at the lateral extremes of the sensillary area. Ridges encircle the sensillary area, running from the sides of the bulla around the sensillary bases and along the posterior margin of the area. These ridges are irregular in shape and are often broken and displaced in mounting. In *Walchia americana* the major ridges pass medial to the sensillary bases instead of around them; small ridges are found lateral to the sensillary bases. Also, in *Walchia americana* the posterior ridge is discontinuous and connected by a small secondary ridge at the midpoint of the posterior end of the area. Body striae enter the sensillary area over the anterior ridge, passing between the bulla and the sensillary bases; the striae are continuous through the depressed area behind the bulla but do not cross the posterior ridge. The posterior apodeme was clearly seen only in *Walchia americana*, where it is much reduced.

All of these genera have sensilla with branches. In species of *Euschöngastoides* the sensilla have very minute branches on their extreme basal portions; these are followed by longer branches for about half the length of the sensillum. The distal half is provided

with much longer attenuate branches. The stem of the sensillum is long and attenuated; near its apex it becomes zigzag in most specimens (fig. 146). Branches arise from at least two planes of the sensillum. The sensillum of *Walchia americana* is similar to that of *Euschöngastoides* but the stem is somewhat thicker and straighter. The sensillum of *Pseudoschöngastia farneri* has a rather thick straight stem, with short basal branches, long attenuate branches in the midregion, and shorter attenuate branches at the apex (fig. 145). The medial branches have enlarged bases, giving the stem a slightly irregular appearance. The sensillum of *P. hungerfordi* is similar to that of *P. farneri* but is usually somewhat expanded medially, presenting a subclavate appearance (fig. 144). Occasional specimens of *P. hungerfordi* have the sensillum very little expanded or not at all, so that it alone would not serve to separate the two species of *Pseudoschöngastia*. One series of *P. hungerfordi* contained no specimens with expanded sensilla.

Scutal punctations are occasionally present but never numerous in the sensillary area or on the crista.

The parascutal setae are much less numerous than in the leeuwenhoekiiine species. Usually they appear to be relatively distinct from the other body setae due to their decreased density. Precise enumeration is difficult; six to fourteen parascutal setae were noted among these species, except for *Walchia americana*. This latter species consistently has but a single pair of parascutal setae. This appears to be a sound taxonomic character as no specimens of other species were found with but two parascutal setae.

The two remaining types of scuta are similar to each other. "Type B" includes species with sensillary bases rather far forward in the sensillary area and the central portion of this area reduced, so that the sensillary area has a reniform shape. "Type C" includes species with the sensillary bases at the middle or back of the sensillary area with the central portion of this area modified and prominent, the appearance of the sensillary area being triangular or transverse. The distinction between these two types, while not clear-cut, is one of convenience.

Species possessing "Type B" scuta are *Cheladonta micheneri*, *C. ouachitensis*, *Neoschöngastia americana*, and *N. brennani* (figs. 149, 154-155, 180). In these species the tectum is provided with serrations or teeth; these are long in species of *Neoschöngastia* and short and broad in species of *Cheladonta*. The tectal seta is longer than the body setae.

The crista is rodlike and plainly connected to the tectum. Lateral keels are present although distorted and often difficult to see. The crista broadens before it reaches the sensillary area in *Cheladonta*; in *Neoschöngastia* the crista reaches the sensillary area before broadening.

The basal plate of the sensillary area in these species arises as a furcation of the crista. In *Cheladonta* (fig. 154) it consists of two bands passing posteriorly beneath the sensillary bases; an opening in the basal plate is found beneath each sensillary base. The basal plate of *Neoschöngastia* (fig. 180) is similar but has a larger, drop-shaped opening for each sensillary base. In *Neoschöngastia* the basal plate appears to terminate at the posterior margin of the sensillary area; the apodeme is either much reduced or absent. The basal plate of *Cheladonta*, however, plainly continues posteriorly to the sensillary area as an apodeme formed from the union of two bands. The apodeme is broad, often marked with irregular openings and often furcate posteriorly.

The bulla of the sensillary area is somewhat reduced in size in *Cheladonta* but still triangular in shape; in *Neoschöngastia* the bulla is much reduced and is hardly wider than the crista in *N. americana*. Ridges from the corners of the bulla pass laterad to the sensillary bases and unite at the back of the sensillary area. In *Neoschöngastia* additional ridges pass medial to the sensillary bases. These ridges are variable in shape and position, apparently due to distortion in mounting. Body striae enter the depressed area behind the bulla from the anterior angles of the sensillary area. Body striae also surround the sensillary bases but do not cross the posterior ridge of the sensillary area.

Punctations are present on the posterior part of the crista and in the sensillary area.

The sensilla are provided with branches, which are tiny on the basal portions and become longer distally. In *Cheladonta micheneri* they are subclavate in shape; in *C. ouachitensis* they are slightly expanded in their midregions but taper again in the distal portion. The sensilla of *Neoschöngastia americana* are similar but slightly expanded distally, and with short branches on the basal half.

Parascutal setae are similar to the body setae but less dense, numbering about ten.

A "Type C" scutum (sensillary area triangular rather than reniform) characterizes the genera *Blankaartia*, *Euschöngastia*, *Speleocola*, and *Trombicula* (figs. 4, 148, 150-153, 156-168, 173). These

genera include about one half of the species in this study. The "Type C" designation is essentially a category for those scuta without unusual modifications.

The tectum is square or triangular in most species; the margin of the tectum is smooth in *Blankaartia* and *Euschöngastia* but provided with serrations or teeth in *Speleocola* and *Trombicula*. In most species the teeth number about eight to twelve; often they are difficult to see and counts seem to be impractical but the presence or absence of teeth usually can be ascertained without difficulty. In the subgenus *Eutrombicula* the teeth are smaller and more numerous, averaging about twenty. A slight central prolongation of the tectum is present in species of the subgenus *Neotrombicula* and in *Trombicula ornata*. A single tectal seta is present in all species; occasionally it is duplicated and in these cases the two setae are in tandem. The tectal seta tends to be elongated in most species of *Euschöngastia*.

The crista is a narrow rod, often of irregular width. Lateral keels were seen in all species except *Blankaartia velascoi*; these are invariably disturbed in mounting and their terminations are obscured.

The sensillary area may be roughly characterized as a transverse oval in most *Euschöngastia*, compared to a triangular shape in the other species. The basal plate is composed of two halves, formed by a furcation of the crista anteriorly; the posterior termination is difficult to see but apparently the two halves are united beneath the posterior ridge. The plate contains openings for the sensillary bases (these are omitted from the illustrations). As with the previous species, the basal plate is indicated on one side of the illustrations by dotted lines. The shape of the central opening of the basal plate may be a useful character for separating some species. The apodeme may be seen as an extension of the basal plate in most *Trombicula* but is reduced to a tiny isolated piece in *T. crossleyi*, *T. merrihewi*, *T. ornata*, *T. trisetica*, and species of *Euschöngastia* except *setosa*.

The bulla is present in all species and is essentially the same shape in most species; an expanded triangular structure at the anterior portion of the sensillary area. The bulla is reduced in size in *Euschöngastia diversa*, *E. peromysci*, *Speleocola tadaridae*, and *Trombicula myotis*; the bulla is elongated anteriorly in species of *Blankaartia*. A median carina is present atop the bulla. This structure is usually flattened in mounting and may be obscured or confused with the walls of the bulla; apparently all of the species

have a carina but it is not always seen. The carina is thickened in some species, particularly in the subgenus *Neotrombicula*. In this group the carina appears to be a thick, slightly elevated structure but may actually be absent. In occasional specimens of many species the carina is doubled at the posterior end.

The sensillary bases have the same structure as described for the other types of scuta. The bases are placed well at the sides; they appear slightly enlarged in *Trombicula crossleyi*, *T. montanensis*, *T. merrihewi*, and *T. trisetica*. This may be a function of the small size of these scuta.

The sensillary area is surrounded by ridges, which include weak ridges from the angles of the bulla, heavy ridges around the out-sides of the sensillary bases, and a rather weak posterior ridge. The ridges encircling the sensillary bases have elevations in front of and behind the bases. A crossbar may usually be found medial to the sensillary base but is usually weak and often distorted. In *Speleocola tadaridae* these crossbars are strong and have elevated flanges on them (fig. 173). Additional crossbars are found irregularly on some specimens. The posterior ridge is usually broken in mounting. In species of the subgenus *Eutrombicula* this ridge has a bilobed appearance caused by two elevated areas, a condition indicated in *Trombicula gurneyi*. Body striae enter the sensillary area at the front, between the bulla and the sensillary bases, while a few striae appear to cross the ridges around the sensillary bases. Striae do not cross the posterior ridge.

On the margin of the sensillary area, near the angles of the bulla, one or two tiny projections may be seen. These are apparently subcutaneous and are inconspicuous except in the genus *Euschöngastia*. In species of *Euschöngastia* (except *E. trigenuala*) these projections are enlarged into rather conspicuous teeth. The limits and extent of the teeth are difficult to make out, owing to confusion with body striae and with lateral keels. Their exact nature is not known.

The sensilla afford usable characters in this group of species. In species of *Blankaartia* the sensilla are long, attenuated, and entirely nude. Sensilla of other species have, at least, tiny basal branches. Species having sensilla which are rather thick but not subelavate and provided with short branches along the entire length include *Euschöngastia criceticola*, *E. cynomyicola*, *E. diversa*, *E. peromysci*, *E. pipistrelli*, *E. setosa*, *Trombicula autumnalis*, *T. fitchi*, *T. lipovskyi*, and *T. sylvilagi*. Sensilla of this type

but with a reduced number of branches are found on *Euschöngastia jonesi* and *Trombicula kardosi*. The sensillum of *Euschöngastia trigenuala* is similar but lacks branches on the distal third of its length. The sensillum of *Trombicula whartoni* is similar in being rather thick but not subclavate, but lacks branches except for minute basal ones. Species having sensilla slightly expanded distally, or subclavate, and provided with rather heavy branches include *Spelcocola tadaridae*, *Trombicula crossleyi*, *T. merrihewi*, *T. ornata*, and *T. trisetica*. Sensilla which are flagelliform, having thin stems, and provided with long fine branches are possessed by *Trombicula belkini*, *T. gurneyi*, and *T. kansasensis*; similar sensilla with numerous fine branches are found on *T. montanensis* and *T. myotis*. Species with similar sensilla but which have the branches less numerous and arising from a single plane include members of the subgenus *Eutrombicula*, except *T. belkini*. In the subgenus *Neotrombicula*, many specimens have sensilla with furcations at the tip; these are rather small and appear to be two normal branches rather than an additional modification of the stem.

A few puncta may be seen in the sensillary area on most specimens. Puncta are exceptionally numerous on species of the subgenus *Eutrombicula* (except *T. belkini*), *Trombicula lipovskyi*, and *T. whartoni*.

Parascutal setae were found to be difficult to count precisely; most species have about eight to fourteen such setae except for members of the subgenus *Eutrombicula*, which have about twenty to thirty, and species of *Blankaartia*, which have about thirty. Except for these extreme cases, the number of parascutal setae would be a difficult character to apply. In *Trombicula crossleyi* and *T. trisetica* a pair of parascutal setae is placed directly in front of the sensillary area, one seta on either side of the crista. These setae are noticeably longer than the other parascutal setae. *Trombicula ornata* has two parascutal setae in the same position which are but slightly longer than the other parascutal setae. In other species, there are usually no setae in this position.

Measurements of the scutum. A series of measurements of the larval scutum has been used successfully for some years. Workers on postlarval stages have taken various measurements of the scutum but there has been no general agreement as to what to measure or how the measurements are to be taken. Audy (1954:128) has proposed an ambitious scheme for taking eleven measurements of the scutum; his system includes the better ideas of other workers but is

still affected by an underlying difficulty, in that the nymphal scutum has few definite points from which to originate or complete a measurement. The larval scutum, in contrast, has five or six scutal seta in addition to the sensilla, and the larval measurements are based upon these definite points.

Both the anterior and the posterior margins of the sensillary area are indefinite; the anterior margin is marked by the gradual widening of the crista, and the posterior margin by the very irregular posterior ridge. Thus it seems that measurements of the length of the crista itself, the length of the sensillary area, the length of the posterior apodeme, or others involving these points would prove impractical. The writer has taken only four measurements, as follows: ASL: Anterior scutal length, measured from the tectal seta to the level of the centers of the sensillary bases. SB: Distance between sensillary bases, measured from the point of insertion of the sensilla. TS: Length of the tectal seta(e). SENS: Length of the sensillum. The ratio ASL/SB provides a quantitative expression of the general scutal shape.

The debatable measurement here seems to be the measurement ASL. The anterior point used could have been the anterior termination of the crista rather than the tectal seta. However in many species the measurement cannot be taken with the oil immersion lens, and the tectal seta is visible under lower magnification although the anterior termination of the crista may not be. At lower magnification it is easier to determine the posterior limit of the measurement; the ocular scale used by the author had long rulings which often spanned the distance between the two sensillary bases. A further difficulty arises in the genus *Walchia*, which lacks a tectal seta. For the single species included in this work, the measurement was taken to about the middle of the tectum (a procedure suggested by the position of the tectal seta in *Pseudoschöngastia*). Workers in the Asiatic Pacific area have to contend with many species of *Walchia* and may well find this procedure objectionable.

Accurate measurements of the lengths of the sensilla are impossible except in the species where they are thickened and straight. In other species estimates of the length were made.

The measurements ASL, SB, and TS are given in the descriptions of species. The measurement ASL is roughly related to the size of the mite and has a large standard error. The measurements SB and TS are rather more independent of size and have smaller standard errors. However, all three of these measurements may be used to separate some species from others, and as such, they provide usable taxonomic characters.

The ratio ASL/SB is also given in the descriptions of species. In table 5 the distribution of this ratio among taxonomic categories is given. This table shows that three general groups are formed: A lower group with mean ratios between 1.2 and 1.7, a central group with mean ratios between about 1.9 and 3.0, and an upper group with mean ratios from about 3.2 to 5.2. The upper group is composed of leeuwenhoekine species, but members of the genus *Blankartia* approach them. The lower group is composed of *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia* (species with a "Type A" scutum). Most species fall into the middle grouping. It is further seen that the generic groupings are fairly distinctive. As more species become known, it may develop that the ratio ASL/SB is a valuable generic character.

THE BODY

This section considers the body and its morphological features not previously treated, namely the setae, eyes, sternum, genitalia, and anus.

Shape. Body shape has been frequently used to characterize trombiculid postlarvae. A classic method for separating trombiculids from their relatives was by body shape; trombiculids were be-

TABLE 5. The Ratio ASL/SB: Distribution of Species among Taxonomic Categories. (ASL and SB are explained in text.)

MEAN RATIO	Leeuwenhoekines	<i>Eutrombicula</i>	<i>Neotrombicula</i>	other <i>Trombicula</i>	<i>Euschöngastia</i>	<i>Pseudoschöngastia</i>	<i>Euschöngastoides</i>	remaining trombiculines
1.2							2	
1.4								1 (<i>Walchia</i>)
1.6						2		
1.8								
2.0					1			1
2.2			3	4	2			2
2.4		1	1	2	1			1
2.6		2		4	4			
2.8		1						
3.0								1 (<i>B. alleei</i>)
3.2	1 (<i>A. arizonensis</i>)							1 (<i>B. velascoi</i>)
3.4								
3.6	1							
3.8	1							
4.2	1							
4.5	2							
5.2	2							

lieved to have a constriction of the body which produced a "figure 8-shape," while trombididiids lacked such a constriction. Subsequently it was discovered that leeuwenhoekiiine genera (except *Hannemania*) lack the constriction; however, all known trombiculine species are constricted. This feature is often destroyed in mounted material and must be used with caution except in fresh or alcoholic material. Another difficulty in applying the body constriction as a diagnostic character separating trombiculids from trombididiids is the presence of slight constrictions in some trombididiid species. The body shape of leeuwenhoekiiines (except *Hannemania*) is a slightly elongated oval (fig. 205). Most trombiculines have a rounded "figure 8-shape" (fig. 202) except for certain species which are noticeably elongated; these are species of *Cheladonta* (fig. 200), *Pseudoschöngastia*, *Trombicula autumnalis*, *T. crossleyi*, *T. merrilhewi*, *T. sylvilagi*, and *T. trisetica* (fig. 1). An elongated body has been suggested as a possible character for *Neotrombicula* but this is not a feature of all members of that subgenus. The body is shortened and strongly constricted in species of *Neoschöngastia* (fig. 201).

Size. As previously mentioned, body size of nymphs is not subject to exact measurement due to extreme distortion in mounting. This is less true of the smaller species than the larger ones; nevertheless, most specimens could not be measured with any feeling of accuracy. Estimates of the body length were made only to tenths of a millimeter; these are given in the descriptions. The range of sizes found was from 0.4 to 1.2 mm. Most of the species are between 0.6 and 0.8 mm. long; species measuring 0.5 or less were characterized as "small" (seven species); those measuring 0.9 or larger were characterized as "large" (nine species). No estimates of width were made.

Eyes. The presence or absence of eyes, and their number and position, is a much-used character in mite taxonomy. Eyes of trombiculids are bright red in life but are sometimes difficult to see in mounted material. Most species lack eyes. Of the leeuwenhoekiiinae species, all have eyes except *Acomatacarus arizonensis* and *Whartonia senase*. The eyes are found in front of the sensillary area at the sides of the propodosoma or nearer the crista. The eyes are double (2/2) in species of *Hannemania* but are single (1/1) in other species. Of the trombiculine genera, eyes are found only in the genus *Blankaartia* where they are single and placed as in the leeuwenhoekiiine species, and in the subgenus *Eutrombicula* where they are single and placed adjacent to the sides of the sensillary

area. In *Blankaartia* the eyes are distinct ovals; in *Eutrombicula* they are less distinct and sometimes have a semilunar appearance, owing to their proximity to the sensillary area. The eyes are clearly visible in *T. alfreddugèsi* and *T. splendens*, but hard to see in *T. belkini* and *T. lipovskyana*. Particularly in *T. belkini*, the presence of eyes is detected in mounted specimens only by the disruption of the cuticular striae. A lens could be seen clearly only in one specimen of *belkini* examined in this study.

Observations on living material in culture disclosed no obvious differences in behavior between species lacking eyes and species possessing them. Species lacking the lenses may well have light-sensitive areas which are not detected in cleared and mounted material.

Setae. A dense coat of body setae is characteristic of the group of mites to which trombiculids belong. Characters involving body setae have been very successfully used among these mites. Typically body setae are branched and so numerous as to form a thick pelage which obscures the integument and even features of the setae themselves. The dorsal setae are somewhat longer and thicker than the ventral ones; those of both surfaces increase in length posteriorly, so that the longest are the posterior dorsal ones. Posterior setae typically arise from tubular elevations each of which is supported by a small circular platelet. The ventral and the anterior dorsal setae arise from less distinct platelets and are but slightly elevated.

Body setae are best observed at the posterior margin of the body. Posterior dorsal setae have been figured for most species. In the following discussions distinct types will be mentioned but not described in detail, since the illustrations better fulfill this purpose.

Primitive body setae are probably the types with simple attenuated stems and simple branches; however, of the leeuwenhoekiiine species only *Chatia setosa* has such setae. Among the trombiculines most species have unmodified attenuated body setae although the stem may be shortened or lengthened, and the tip of the stem may be modified. Body setae with straight but thickened stems are found in *Hannemanina* and some species of *Trombicula*.

A usual type of tip found on the posterior body setae is a division of the attenuated stem into two or three short branches. Modifications of the tips are often so constant as to form valuable generic or specific characters. *Chatia setosa* and *Euschöngastia pipistrelli* possess body setae with single, very long, attenuated tips. Species of *Hannemanina* have body setae which terminate in a curved, al-

most hooklike spine. Body setae of *Trombicula myotis* terminate in hyaline knobs. Very tiny branches are found in groups at the tips of the body setae of some species, including *Euschöngastoides loomisi*, *Walchia americana*, some species of *Trombicula*, and particularly some species of *Euschöngastia*. In the latter genus a transition may be seen from a seta with a simple tip (*E. criceticola*) through one with short branches on the tip (*E. diversa*, *E. setosa*) and a seta with the stem and its tiny branches offset at the tip (*E. jonesi*) to a seta with many tiny branches over the tip and even distributed along a dominant lateral branch (*E. peromysci*). Relatively small branches are found near the tips of setae of most species of *Trombicula*.

Modifications of the usual shape of the setae include the peculiarly expanded setae of *Acomatacarus* and *Cheladonta*, and the leaflike setae of *Whartonia senase*. Compound branching is found in the setae of species of *Neoschöngastia* and *Speleocola tadaridae*. The setae of *Trombicula fitchi* are peculiar in the arrangement of the branches; long branches are found on the basal half but only short, thick-based branches occur on the distal half. Setae of *T. kardosi* are similar to these but occasional long branches are found among the shorter ones.

The increase in length posteriorly is usually a gradual transition, but in *Euschöngastia pipistrelli*, *E. trigenuala*, and *Trombicula fitchi* the change is abrupt; posterior setae are strikingly longer than the adjacent dorsals. Intermixed long and short body setae are found on *Acomatacarus arizonensis* and species of *Neoschöngastia*.

The lengths of various body setae have been used as specific characters with some success. Certain difficulties arise, however, when measurements of these setae are attempted. Modifications of the tip often make the exact termination of the seta obscure; lateral branches may exceed the tip of the stem in length and these are so flexible that only an approximate length can be obtained. Setae which end in fine tips cannot be measured accurately. Even the relatively unmodified setae can be exasperating in this respect. The writer found it impossible to obtain the same figures in re-measuring setae of *Trombicula alfreddugèsi* and *T. splendens*. Authors have recommended the measurement of setae from various parts of the body, but since the setae increase in size posteriorly, these measurements are useless unless the exact location of the seta is specified. The writer measured only posterior body setae; these figures are given in the descriptions as approximations. A

continuous range of values was found from about twelve to about one hundred and five microns. Variation among individual specimens seems to be about twenty microns in the species with larger setae and less in those with smaller ones. The central posterior dorsal setae on a single specimen appear to show less variation than occurs between individuals. All in all the length of the posterior body setae is a usable character if not too strictly applied; species towards the extremes may be separated easily from others but species with setae of similar length should be compared with caution as to this character.

Sternum. The sternal area lies between the coxae of legs I and II. Recently Womersley (1952:18) found several taxonomic characters associated with the sternum. Some species (*Guntherana*) have precoxal plates of coxae I present, other species (*Trombicula*, subgenus *Leptotrombidium*) have these precoxal plates of coxae I fused to form a longitudinally divided sternum, and most species (most *Trombicula*) have the longitudinal division obliterated so that a sternal area remains which is closed behind by a crossbar connecting coxae II. In *Gahrlepiea* (= *Walchia*) Womersley found no evidence of a closed sternum formed by fusion of precoxal plates.

Of the species in the present work, only *Neoschöngastia* was found to have precoxal plates (fig. 177). (Womersley, 1952, included descriptions of three species of *Neoschöngastia* but did not mention the sternum.) A longitudinally divided sternum is present in *Trombicula* (*Leptotrombidium*) *myotis*, which agrees with Womersley's findings.

The sternum in the leeuwenhoekiiine species consists of a sclerotized plate bearing eight or ten setae. In the other (trombiculine) species the sternum is closed behind by a bar connecting the coxae of legs II, with certain exceptions. *Speleocola tadaridae*, *Trombicula crossleyi*, *T. merrihewi* (fig. 181), *T. ornata*, and *T. tristetica* have sternal areas which are elongated posteriorly and open behind; however, some specimens show a very weak incomplete bar between the coxae II. Apparently the closure has been secondarily lost in these species, perhaps as a consequence of change in shape of the sternal area or decrease in general size. Other species have a sternum of pentagonal to rectangular shape (or elongated in *Euschöngastia jonesi* and *Walchia americana*) which is closed behind, although the posterior bar is weak in some species and sometimes is incomplete. (*Walchia americana*, in contrast to Womers-

ley's observations on that genus, has a closed sternum.) Occasional specimens (particularly specimens of *Cheladonta* and *Walchia americana*) show a trace of a longitudinal division of the sternal area. This would seem to lend support to Womersley's suggestion that the closed sternum is derived from fused precoxal plates. However, some leeuwenhoekine species have a posterior thickening of the sternal plate which resembles the closure of the trombiculine sternum.

Setae on the sternum are usually of the ventral body type (but different in *Acomatacarus* and *Whartonia senase*). About eight setae are usually found in the sternal area; larger species have about twelve setae and smaller ones about four to six. The setae were not counted on all specimens but the variation noted was large (about six to fourteen sternal setae in *Trombicula splendens*).

Genitalia. The genital opening (fig. 12) is located between or immediately behind coxae IV. The genital areas of all species resemble one another very closely. Most external is a pair of elongated plates which bear branched setae similar to those of the body; the genital opening is between these two plates. Mesal to these, and extending across the genital opening, is a pair of elongated plates which bear the three pairs of genital setae. These setae (figs. 13-15) are invariably six in number and are usually nude but occasionally forked or branched. Rarely one or two of the genital setae resemble the fanlike genital setae of the adult male (see fig. 15). This phenomenon may be the expression of an adult character in the nymphal stage, but it would appear that sex is not consistently expressed in the nymphs in this manner since very few specimens show this character. The two pairs of genital suckers are located beneath the plates in the midregion of the genital area. Their function is unknown. Their size appears to be variable, and their relative size was found to be inconstant in a series of specimens.

Anus. The anus is located posterior to the genital opening. The anal opening itself is not evident; the term "anus" is applied to the plate or plates guarding the presumed position of the opening. In the leeuwenhoekine species (fig. 197) the single anal plate is circular or oval, poorly sclerotized, not obviously divided, and usually distorted in mounting. The anal opening of trombiculine species (fig. 199) is obviously guarded by two elongated shoelike plates, each of which bears a number of setae. No further characters associated with the anus were found.

LEGS

Characters involving the legs of trombiculid postlarvae have been virtually ignored, probably because of the plethora of setae found on them. In the classification based on larvae, features valuable in taxonomy include the number of leg segments and the number of modified setae on certain segments.

All of the species included in the present study have, as nymphs, seven segments in the legs; these are coxa, trochanter, basifemur, telofemur, genu, tibia, and tarsus. A pretarsus, consisting of a pair of claws, is present on the tarsus of each leg. Except for several exceptions the relative shapes of the various segments appear to be the same for all species. Leg setation, also, is very similar among the various species. Therefore the following discussion will be general, particularly in regard to leg setae.

Usually the legs are slightly shorter than the body, leg I being the longest and largest. In *Chatia setosa* (fig. 190) the legs are noticeably elongated, leg I being obviously longer than the body and the other legs about as long as the body. Legs appear slightly shortened in some species and particularly in species of *Cheladonta*, but others (*Euschöngastoides*, *Neoschöngastia*, *Pseudoschöngastia*, and some *Trombicula*) approach this condition. The coxa is a rather flat, cylindrical segment which appears to be slightly movable. The trochanter is a small, somewhat arched segment. Articulations between coxa and trochanter and between trochanter and basifemur are dicondylic; the former permits dorsal-ventral movement and the latter anterior-posterior movement of the more distal segments. Articulations between remaining segments are monocondylic and dorsal. The distal segments are cylindrical, about as long or longer than broad. Shape of tarsus I appears distinctive for certain species, these being the somewhat pyriform tarsi of *Acomatacarus* and *Whartonia senase* (figs. 187, 189), and the rather rounded tarsus of *Cheladonta* (fig. 184). Otherwise tarsi are generally similar in shape. *Walchia americana* possesses a short stump which projects from the distal dorsal portion of tarsus I (fig. 188).

Two measurements were taken on tarsi I, these being the length (TL), measured from the dorsal articulation to the ventral tip, and the thickness (TH), measured at the widest point. The ratio TL/TH was computed. These figures with their standard errors are given in the descriptions. Generally the size of the measurement reflects the size of the mite. The ratio TL/TH has

a rather small range among most species; however, the standard error is small and this character is useful in separation of some species. No groups of species were distinguished either by the measurements or by the ratio.

Leg segments, especially the more distal ones, are covered with setae. While the number of nude or branched setae on a segment is constant for the species in many larvae, the number of both types varies among specimens of postlarvae. Audy (1954:128) has proposed a scheme for tabulating the number, type, and location of leg setae. The writer used a somewhat simplified modification but abandoned the project as being laborious and unproductive. All in all, the tabulation was completed for six species; the following description is based upon this information and upon less precise observations on the other species.

Interspecific variation in the number of setae per segment was found in all species and on all segments. Coxal setae resemble the ventral body setae; straplike extensions of the coxae I extend towards the dorsum and these bear elongated setae. The trochanter bears branched setae which are elongated and placed in a band across the segment; the number of setae found was three to five on the smaller species and seven to nine on the larger ones. Branched setae on the remaining segments become increasingly modified distally; the setae become unipectinate and the branches become straight and increasingly fine. Setae on the tarsus may be described as comblike. Branched setae on the legs are slightly expanded in species of *Acomatacarus*, *Leeuwenhoekia americana*, and *Whartonia senae*. Nude setae first appear on the telofemur, which has zero to two dorsal nude setae. The remaining distal segments have increasing numbers of nude setae, particularly on leg I. On tarsus I nude setae are extremely numerous. On the remaining leg segments the nude setae do not become so numerous and can be counted. The genu and tibia have about six to fifteen dorsal nude setae. The tarsi of legs II, III, and IV have fewer nude setae and occasionally lack nude setae altogether.

Audy (1954:128) distinguished several types of nude setae, from blunt, striated, nearly flask-shaped setae to attenuated, unstriated setae, and noted the occurrence of microsetae. These types (except microsetae) tend to grade into one another in the material examined by the writer. Nude setae of the more proximal segments tend to be unstriated and attenuated, although blunt striated setae are not excluded. Tarsi II, III, and IV usually have at least one

long untapered striated seta reminiscent of the tarsala of the larval stage; however, the seta may be absent and often more than one is present. Another feature of these tarsi is a slight recurved seta on the dorsal distal margin, which resembles the subterminala of the larval tarsi I. These setae are not at all constant in occurrence. Variation in nude setae appears to be of such magnitude as to require a precise tabulation such as that proposed by Audy, if characters involving these setae are to be found.

Useable characters no doubt exist in leg setation but the most likely ones appear to be those involving counts of setae on the more proximal segments, rather than features of the types of nude setae. At any rate a considerable amount of laborious tabulation is needed before these features can be utilized.

RELATIONS OF MORPHOLOGY TO HABITS AND ENVIRONMENT

Little is known of the habits and natural habitats of postlarval trombiculids, since the postlarval stages are not often collected. Loomis (1956), however, gives what he believes to be the habitat of the postlarval stages for most of the species considered in the present paper.

Trombiculid postlarvae are dwellers in soil or in similar substrates. The habitats suggested by Loomis include grassland and woodland soils, mammal nests or burrows (and soil associated with these), decaying wood, crevices in rocky outcrops, and bat caves. Quite possibly all of these habitats provide a substrate of similar physical conditions (perhaps a somewhat granular substrate in which the mites can burrow) so that little adaptation to the physical makeup of the substrate of different habitats is needed. At any rate there are no consistent morphological differences between species in different habitats. Species which occur in decaying logs (*Trombicula splendens*, for example) may be morphologically similar to close relatives which occur in soils (in this case *Trombicula alfreddugèsi*). Larvae of *Trombicula merrihewi* have been taken only from bats, and larvae of *T. ornata* have been found only on rodents, yet the nymphs of these two species are quite similar. From this it appears that the postlarval habitat as suggested by larval host preferences, does not provide sufficient information to permit conclusions concerning the relationships of morphology to habitat.

Additional information is available from seasonal occurrence and observations on cultures. Since some species show marked differences in seasonal abundance in the larval stage, it may be assumed that their postlarvae have different temperature requirements and tolerances. Within the genera *Trombicula* and *Euschöngastia*, nymphs of winter species of chiggers tend to have stouter cheliceral bases and wider cheliceral blades than do nymphs of summer chiggers. There are some exceptions to this tendency. It seems unlikely that this modification is directly associated with temperature tolerances.

Observations on cultures indicate that nymphs of similar species have different humidity requirements (Wharton and Fuller, 1952: 149). If there is a relationship between morphological features and humidity requirements in trombiculid nymphs, it is not an obvious one. The postlarvae of *Whartonia senase* seemingly occur in very dry habitats, and their leaflike body setae possibly provide protection against desiccation. Such modifications are not seen among other nymphs which may inhabit very dry situations. Species of *Hannemania* and of *Blankaartia*, whose postlarvae must exist in very moist habitats, show no features which are clearly adaptations to such environments.

Gross culture observations disclosed no differences in behavior between postlarvae which have eyes and those which lack eyes. Nevertheless, it happens that those postlarvae which are not uncommonly collected in the field are those which have lenses (*Blankaartia* in Panama and *Eutrombicula* in many regions); possibly these species more readily come to the surface and are detected by collectors. This does not hold true for species in the subfamily Leeuwenhoekiinae, nymphs of which usually have lenses but are not commonly collected.

The food material taken by nymphs in culture offers additional information concerning their habits. Although data are not available for all species, the general picture is as follows. Insect (Collembola) eggs only: *Euschöngastia*, *Trombicula* (and probably *Blankaartia* and *Speleocola*), and *Hannemania*. Collembolans only: *Cheladonta*, *Neoschöngastia*, *Pseudoschöngastia*, and *Walchia*. Did not feed: *Euschöngastoides*. Information is inconclusive for the remainder of the genera (all leeuwenhoekiines). Some specimens of *Trombicula* occasionally eat active collembolans.

Those species which eat active prey show gnathosomal modifications possibly associated with their food habits. The genera

Cheladonta and *Neoschöngastia*, particularly the former, have elongated gnathosomal elements which possibly assist in the capture of prey. The genera *Pseudoschöngastia* and *Walchia*, however, have shortened gnathosomal elements. These latter genera have a more heavily sclerotized pharynx with reticulate markings, which suggests more powerful musculature.

COMPARISON OF LARVAL AND NYMPHAL MORPHOLOGY

This section includes an abbreviated account of larval morphology for comparison with the nymphal morphology. Emphasis is placed upon those forms for which the nymphal morphology is described. More detailed accounts of larval morphology may be found in Wharton and Fuller (1952:30) and, for Kansas materials, in Loomis (1956:1223).

The larva is six-legged rather than eight-legged but otherwise is essentially similar to the nymph in gross morphology. The body is at most only slightly constricted; it is capable of distention during engorgement. There is no closed sternum between legs I. The genital opening is absent. The scutum is not modified into a linear stricture but retains its platelike nature. Rarely caudal plates are present on the posterior dorsum of the abdomen.

The cheliceral base is short and the blade pointed. In most species teeth of the cheliceral blade are restricted to the "tricuspid cap," which consist of a dorsal tooth, a ventral tooth, and the point of the blade. In species of *Hannemania* the cheliceral blades are expanded distally and provided with additional teeth. Species of *Chelandonta* have a ventral row of minute serrations on the cheliceral blade. Only species of *Acomatacarus* and *Whartonia* have teeth on the dorsal margin of the blade, as do most nymphs.

Palpi of larvae are of rather similar shape. There is no distinct trochanter. The setal arrangement is mostly constant. There is one dorsal seta on the femur, and one dorsal seta on the genu; the tibia has one dorsal, one lateral, and one ventral seta. The condition of these palpal setae (whether nude or with branches) is a specific character. There are no accessory claws; the major claw is present and is presumably always branched, thus differing from that of the nymph. The number and arrangement of these branches is a specific character and to some extent a group character. The vestiture of the palpal tarsus is variable but has been little studied.

Other features of the gnathosoma have been little used. The galeal setae are seemingly homologous to the apical hypostomal setae of the nymph. The galeae are paired processes which appear to curve dorsally around the chelicerae. Each bears a seta; the characteristics of these setae are used as specific characters.

The scutal plate contains the characters most used in larval classification. Basically this is a rectangular plate bearing several setae. One anteromedian seta is present in most species (paired in *Leeuwenhoekinae*, absent in *Walchia*). The four corners each bear a seta in most species, but in *Pseudoschöngastia* the posterolateral setae are off the scutum and *Walchia* bears additional posterior setae. Scutal shapes are correspondingly modified; the scutum is shortened in *Pseudoschöngastia* and lengthened in *Walchia*. The shape of the scutum has been used as a specific character and sometimes as a group character. Most species of *Euschöngastia* have broad short scuta. Species of *Trombicula* have scuta which vary from rectangular to pentagonal, with the apex directed posteriorly. In *Neoschöngastia* the scutum is partially submerged beneath the cuticular striae. *Leeuwenhoekii* genera (except *Whartonia*) have a small anteromedian projection on the anterior margin. The sensilla vary from flagelliform to expanded. The nature and degree of branching is used as a specific character among those species with flagelliform sensilla. When expanded, the degree of expansion is used as a specific character; these sensilla are all more markedly enlarged than any of the sensilla of the postlarval stages. Expanded sensilla are characteristic of the genera *Cheladonta*, *Euschöngastia*, *Euschöngastoides* (one of two species), *Neoschöngastia*, and *Pseudoschöngastia*. Scutal markings associated with the sensillary bases are used as specific characters. A series of ten "standard" measurements taken on the scutum are used as specific characters. Scutal modifications in the larval stages do not seem to be related to modifications in the nymphal stage.

Shapes and details of branching of body setae have been used as specific and sometimes generic characters; usually these setae are not so strongly modified as are those of the nymphs, and the characters have not been extensively used. The body setae of the larvae are arranged in rows and can be easily counted; their number and arrangement are specific characters.

Some group and specific characters are taken from the legs. Legs contain six or seven segments, depending on the division of or fusion

of the femur. In the leeuwenhoekiiines all legs have six segments. Trombiculine species have seven segments in leg I and usually seven in legs II and III; *Walchia* and *Pseudoschöngastia* clearly have six segments in legs II and III, and it is difficult to determine whether the femoral division is complete in some other species. The setation of the legs is sparse and constant, so the number and nature of leg setae is a widely used specific character.

Characters which retain similar states in both larval and postlarval stages would be of considerable interest, since it would be possible to predict the characters of one stage from those of the other. However, such characters are very few. Sasa (1953:429) mentions three features which are similar in larva and postlarva, these being color, nature of the basal part of the sensillum, and number of anteromedian and tectal setae. The present writer must find fault with the first two of these.

The color shown by trombiculids is undoubtedly influenced by environment and by age, as may be seen in cultures. Although some species show little color variation (for example, species of *Pseudoschöngastia* and *Walchia*) others show a wide range. Larvae of *Trombicula montanensis* range in color from white to dark orange; nymphs range from yellow to orange. The writer has placed larvae in culture which he characterized as "yellow"; nymphs produced from these larvae were characterized as "orange." On the other hand, Loomis (personal communication) has collected and cultured adults of *Trombicula splendens* (normally red) which were white; larvae obtained from these adults were also white. Thus, while the color of larval and postlarval stages is related and may be similar, variation is great enough that the writer would hesitate to predict the color of one stage from that of the other.

Since a character that has been emphasized in studies of the larval stage is the sensilla (whether flagelliform or expanded) any similar or related modifications of the sensilla of the postlarval stages would be of greatest interest. Unfortunately no such related modifications were found; it is not possible to tell from the sensilla of the nymph whether the larva had flagelliform or expanded sensilla. Sasa observed that some species of *Leptotrombidium* have similar short basal branches on the sensilla in both larval and postlarval stages. This must be regarded as an exceptional case; no constant relationship appears among the species studied by the writer.

The number of anteromedian setae on the larval scutum is directly related to the number of tectal setae on the adult scutum, as

reported by Sasa and by others. Leeuwenhoekine species have two tectal setae and two anteromedian setae; species of *Walchia* have no tectal setae and no anteromedian setae, while other trombiculines have one tectal seta and one anteromedian seta. The nature of the tectal setae (length, modification of stem, and details of branching) are perhaps related in some species but not in most.

Other features occasionally show similarities in larva and post-larva for some species. For example species with large larvae often have large nymphs, but this relationship is far from constant.

Trombiculid mites are certainly not unique in this exhibition of independent variation of characters in two differently adapted stages. Where two stages lead different modes of existence, such independent variation is an obvious advantage, since characters selected for in one stage need not be exposed to adverse selection in subsequent stages. Seemingly natural selection has built up a group of genes which do not express themselves (or have little expression) in the larval stage but which have their major effects in the postlarval stages. The metamorphosis of holometabolous insects is a similar and better-known phenomenon.

When considering these problems it is necessary to bear in mind constantly that the larva, nymph, and adult of an individual are all the same animal; that there is but one genotype for the individual; and that the effects of selection on the characters of any one stage will be felt upon the entire genotype.

TAXONOMY OF THE NYMPHAL STAGE

Nearly all of the species and group names used in this study are based upon the larval stage. Only about half of the established genera are known as postlarvae, and but a small fraction of the described species are known as postlarvae. These circumstances make difficult the construction of group diagnoses and keys; one is hesitant to characterize a genus on a few species when he is aware of the existence of many more species, and perhaps he has not even seen the type of the genus, which he certainly should consider. Womersley (1952) has provided keys to genera and species but usually omits a formal diagnosis for groups, Sasa's (1952) excellent work lacks even keys, and Wharton and Fuller (1952) include only the postlarval characterizations of some groups. The present writer has chosen to use the species at hand as the basis for a full description for each genus, including most characters common to all included species. These descriptions will undoubtedly require modification as more postlarvae are described, but

they may provisionally serve the purpose of a source for critical comparison. In the construction of these descriptions the previously described species were considered; however, as most forms are inadequately known, it was not possible to tell how accurately these fit the generic descriptions. In certain cases previously described species do not agree with the generic characters. These species are provisionally placed in genera but the generic diagnoses will obviously have to be modified when these species are better known and can be classified with greater certainty.

The keys include most of those genera known as postlarvae, but some are inadequately described and were not placed in the keys. These keys were designed primarily for nymphs but will probably classify most adults as well. Keys to species are given; however, in most cases it was possible only to include those species seen by the writer. These specific keys will have little value except in the midwestern region of the United States, but it is hoped that they can be of use also in the study of other postlarvae when they are known.

In the generic diagnoses, characters are numbered and are presented in the same sequence for each genus; the numbers facilitate comparisons and discussions. Within each subfamily each character retains its number for all generic descriptions, but the systems are different for the two subfamilies. Particularly important characters in generic recognition are italicized.

In descriptions, the synonymy of each species is not complete, but includes only the original citation, some different name combinations, and important references to larva or postlarva. Complete synonymies for most included species may be found in Wharton and Fuller (1952) augmented by Loomis (1956).

Group characters are not repeated in the specific descriptions. Measurements are given in microns, except where indicated; means followed by their standard errors are used where possible. Setal counts on the palpal tibia and tarsus include only branched setae; the nude seta at the base of the palpal claw, the tarsala, and the apical nude setae of the tarsus are not included in these counts.

In the listing of specimens examined, a uniform procedure was followed similar to that of Loomis (1956). First is given the total number of nymphs examined by the writer. Then follows the collection data pertaining to the larval hosts of these nymphs, in the following order: State, county, exact locality (where known), host, and the date host was taken. The collector of the host is omitted in most cases; usually these animals were taken by the University

of Kansas Chigger Project and were either obtained by Richard B. Loomis or catalogued by him. Lastly, for each collection the number of nymphs examined is given, with an indication of the persons who reared them. Workers on the Project are identified by initials, as follows: DAC: D. A. Crossley, Jr.; EHK: Ervin H. Kardos, LJJ: Louis J. Lipovsky; RBL: Richard B. Loomis. Also, where nymphs were identified by recovering their larval skins, this is indicated in parentheses. Otherwise, nymphs were identified by association of larvae or by comparison with other nymphs.

FAMILY TROMBICULIDAE Ewing

Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 101.

Diagnosis (nymph).—Body small to medium in size (about 0.4-1.2 mm.); white to red in color; constricted or not; oval to somewhat elongated; provided with numerous branched or modified setae. Eyes sometimes present, 1/1 or 2/2, anterior to or adjacent to sensillary area. A rectangular to pentagonal closed sternum usually present between anterior coxae; sternum sometimes open behind, precoxal plates of coxae I sometimes present; sternal area sclerotized or not. Genital opening between coxae IV; genital plates bearing six genital setae in addition to body setae; only two pairs of genital suckers. Anus posterior to genital opening, divided or not. Legs in two groups; each leg of seven segments and bearing a pair of claws; both branched and nude setae numerous on legs, particularly legs I; tarsus I with or without apical stumplike process.

Gnathosoma with basis capituli evident as a sclerotized ring, bearing hypostome, palpi, and chelicerae. Pharynx usually indistinct but rarely visible due to reticulate markings. Hypostome usually pointed, projecting; occasionally blunt; bearing about eight usually nude, apical setae or about twenty nude or nearly nude apical setae. Chelicerae composed of base, blade, and inconspicuous pseudochela; base stout to elongated; blade usually shearlike, sometimes daggerlike or strongly curved, usually with dorsal teeth or serrations. Palpi composed of five segments: trochanter small, without setae; femur large, with branched setae; genu large but smaller than femur, with branched setae; tibia small, somewhat pointed, bearing claw at apex and usually two subapical accessory claws, several branched setae, and a nude seta on lateral surface at base of claw; tarsus small, articulated to ventral surface of tibia, bearing several usually branched setae, one tarsala, and one to several short apical nude setae.

Scutum composed of anterior membranous tectum, rodlike crista, and posterior sensillary area. Tectum large to small; usually hyaline but sometimes slightly sclerotized; margin smooth or bearing teeth or serrations; with one, two, or no tectal setae. Crista usually a thin rod, sometimes very thin or broadened; sometimes with prominent punctation. Sensillary area variable in shape, from circular to transverse-oval or triangular; variously modified; bearing two sensilla, these flagelliform to subclavate and usually with branches; area usually surrounded by ridges; usually with a posterior apodeme.

Remarks.—The combination of bladelike chelicerae (never elongate-stylettiform), no more than two tectal setae, and a single pair of sensilla on the scutum, will separate trombiculid nymphs and adults from most of the genera in the trombidoid complex. The constricted, “figure 8-shaped” body is not characteristic of all genera but is nevertheless a useful field character.

Extensive larval diagnoses have been given by Wharton and Fuller (1952:40) and by Loomis (1956:1229).

Family rank is accorded these mites by most workers, although some prefer a subfamily rank in the family Trombidiidae. Womersley recognizes two families, Trombiculidae and Leeuwenhoeekiidae. The proper position must, of course, be decided by comparison of the chiggers with their closest relatives, which are obviously the trombidiids. Such a comparison has been quite difficult, since trombidiids are mainly known from their adult stage, while trombiculids are mainly known as the larval chiggers. More recent studies of reared material have increased knowledge of both groups and the result is an increasing difficulty in separating them. The trombidiid genus *Neotrombidium*, for example, is morphologically more similar to leeuwenhoeekine genera than to most trombidiid genera. The biological character of vertebrate parasitism by trombiculids and invertebrate parasitism by trombidiids will exclude these questionable genera from Trombiculidae; they may be excluded on morphological grounds by a rigid and perhaps artificial definition such as that given above. However, these techniques do not solve the problems of the limits of the trombiculid group or place them in their proper taxonomic position.

At the present time the best solution appears to be retention of the family rank for trombiculids, until such time as the accumulated evidence either verifies the position or forces a change to subfamily (or superfamily) status. Knowledge of trombidiids is still fragmentary; trombiculids are better known but still require

extensive taxonomic investigation at the higher levels. The evidence for change at the present must be judged inconclusive.

Subfamilies.—Most workers divide the Trombiculidae into four subfamilies, these being Trombiculinae, Walchiinae (= Gahrlipeinae), Leeuwenhoekiiinae, and Apoloniinae. The two latter subfamilies Womersley places in Leeuwenhoekiiidae. As no species of Apoloniinae are known as postlarvae, this subfamily must be omitted from the following discussions.

The subfamily Walchiinae has recently become a trouble-spot in chigger taxonomy. Wharton and Fuller (1952:41) separate Walchiinae from Trombiculinae in the larval stage by the number of segments in legs II and III; Walchiinae have but six segments, the femurs being undivided, while trombiculines have seven segments due to the division of the femora into basifemur and telofemur. Some workers, including the writer, have experienced difficulty in using this character. Womersley (1952:278) resolved the problem by removing to Trombiculinae the genera *Pseudoschöngastia* and *Walchiella*, and considering the remaining genera congeneric with *Gahrliepia* (with the subfamily name Gahrlipeinae). Larvae were diagnosed by the absence of the anteromedian scutal seta (present in Trombiculinae) and postlarvae were recognized by the presence of an apical stumplike process on tarsus I (absent in Trombiculinae). Audy (1954:161) and Loomis (1956:1362) followed Womersley's arrangement but expressed doubts as to the propriety of recognizing only the genus *Gahrliepia*.

The writer's studies of postlarval stages show that *Walchia* is closely similar to both *Pseudoschöngastia* and *Euschöngastoides*; it appears that a subfamily would have to contain all three of these genera. However, such a subfamily would be difficult to diagnose on the characters based on the larval stage, since the included species would combine such features as anteromedian scutal seta present or absent, scutum reduced (*Pseudoschöngastia*) or extended (*Walchia*), sensilla globose or flagelliform (*E. hoplari*), and legs II and III six- or seven-segmented. Also, larvae of species of *Euschöngastoides* and perhaps *Pseudoschöngastia* are very similar to some undoubted trombiculines. Nevertheless, the impression remains that these three genera form a natural group. It may be that further studies on the larval stage will produce characters which justify the recognition of a subfamily in spite of the diversity in that stage. Until this is accomplished the subfamily Walchiinae (or Gahrlipeinae) must be abandoned as a synonym of Trombiculinae.

KEY TO SUBFAMILIES OF TROMBICULIDAE (NYMPHS)

1. Tectum with two setae, usually side-by-side; sensilla long, flagelliform, without branches; setae on palpal genu less numerous than those on palpal femur..... *Leeuwenhoekinae* p. 192
- 1'. Tectum with one seta or without setae; sensilla variable, with at least short basal branches (except *Blankaertia*); setae on palpal genu more numerous than those on palpal femur, or the same number on those segments..... *Trombiculinae* p. 205

Subfamily Leeuwenhoekinae Womersley

Womersley, 1944, Trans. Roy. Soc. South Australia, vol. 68, p. 102.

Diagnosis (nymphs).—Body oval, not constricted (except *Hannemania*). Tectum with two setae, usually side-by-side. Sensilla long, flagelliform, without branches. Anus circular, not obviously divided into two shoelike portions. Setae on palpal genu less numerous than those on palpal femur.

Additional features (nymphs).—Body with eyes present or absent, 1/1 or 2/2, anterior to and separated from sensillary area; sternal area sclerotized but no true sternum formed by a crossbar connecting coxae II; precoxal plates never present. Gnathosoma with cheliceral base of usual shape (mean ratio BL/BH: 1.8-2.4), cheliceral articulation with basis capituli ventral; two accessory claws on palpal tibia; pharynx inconspicuous, not marked with reticulate pattern. Scutum with tectal margin smooth; mean ratio ASL/SB: 3.2-5.1; bulla absent; lateral keels absent; carina absent; basal plate of two straplike bands; only posterior and lateral ridges on sensillary area; apodeme present.

Included genera.—Known from both larvae and postlarvae: *Acomatacarus* Ewing, *Chatia* Brennan, *Hannemania* Oudemans, *Leeuwenhoekia* Oudemans, and *Whartonia* Ewing. Known from larvae only: *Odontacarus* Ewing and *Shunsennia* Jameson and Toshioka.

Remarks.—The included genera are substantially separable from the trombiculine genera, so that the subfamily status is merited. As previously mentioned, Womersley (1945:47) has given the group full family rank, but was not followed by Wharton and Fuller (1952:96). The present writer also prefers to retain the subfamily rank.

The genus *Odontacarus* (known only as larva) contains but two species. According to Wharton and Fuller (1952:103), "the specimens in existence are too badly damaged to study satisfactorily." "Probably a synonym of *Acomatacarus* (*Acomatacarus*)."

Nymphs of *Shunsennia* have been reared and are being described by Lipovsky (personal communication). All other genera are known as postlarvae, but three of five subgenera of *Acomatacarus* are known as larvae only.

Leeuwenhoekiiine larvae are found on amphibians, reptiles, birds, and mammals. The postlarvae are apparently adapted to various habitats.

KEY TO GENERA OF LEEUWENHOEKIINAE (NYMPIIS)

1. Body constricted; posterior body setae elongated, each ending in a hooklike spine *Hannemania* p. 200
- 1'. Body not constricted; posterior body setae not ending in hooklike spines 2
2. Posterior body setae with simple branches; setal tips single, long, attenuated *Chatia* p. 198
- 2'. Posterior body setae modified, not ending in single, long attenuated tips 3
3. Posterior body setae leaflike *Whartonia* p. 203
- 3'. Posterior body setae somewhat expanded 4
4. Tarsus longer (mean ratio TL/TH: 6.2), cylindrical in shape
..... *Leeuwenhoekia* p. 193
- 4'. Tarsus shorter (mean ratio TL/TH: 2.1), rather pyriform in shape
..... *Acomatacarus* p. 195

Genus *Leeuwenhoekia* Oudemans

Leeuwenhoekia Oudemans, 1911, Ent. Berichten, vol. 3, p. 137 (type *Heterothrombium verduni* Oudemans).

Diagnosis (nymph).—(1) Body shape, oval, not constricted. (2) *Posterior body setae modified, expanded.* (3). *Ratio TL/TH about 6.2.* (4) *Tarsus I cylindrical.*

Additional features (nymph).—(5) Body size medium (about 0.8 mm. long). (6) Eyes 1/1. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) *Legs not unusually elongated; branched setae slightly expanded.* (10) Cheliceral blade shearlike. (11) Palpus moderate in size; claw moderate in size; tarsus with about nine branched setae and six or seven apical nude setae. (12) Hypostome pointed, projecting, with about eight apical nude setae and about twenty ventral branched setae. (13) Basis capituli of normal shape. (14) Tectum large, well sclerotized, saggitate in shape; tectal setae elongated, not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; mean ratio ASL/SB: 5.1. (17) About ten to fifteen parascutal setae.

Remarks.—Wharton and Fuller (1952:96) recognize but two species of *Leeuwenhoekia* in two subgenera; these are *verduni*

(Oudemans) in the typical subgenus and *americana* (Ewing) in the subgenus *comatacarus* Ewing. Since *verduni* has not been reared, the above description is based upon *americana* only.

Lecuwenhoekia as represented by *americana* is very similar to *Acomatacarus* (*Acomatacarus*); these two may be separated by the shape of tarsus I as evidenced by characters (3) and (4) but these are of doubtful generic significance (some postlarvae of *Acomatacarus*, as described by Womersley, probably key to *Lecuwenhoekia*). If *americana* is really congeneric with *verduni*, the *Acomatacarus* is probably a synonym of *Lecuwenhoekia*.

Lecuwenhoekia americana (Ewing)

(Figs. 18, 62, 96, 97, 140, 185, 197)

Comatacarus americanus Ewing, 1942, Jour. Parasit., vol. 28, p. 490 (*larva*).

Lecuwenhoekia (Comatacarus) americanus, Wharton and Fuller, 1952, Mem.

Ent. Soc. Washington, no. 4, p. 96 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1234-1235 (*larva*).

Description of nymph.—Body: About 0.8 mm. long, color yellow. Eyes red in life, about 12 μ in diameter. Setae expanded; tips rounded; branches thick; posterior setae about 20 μ long. Sternal area containing nearly square sclerotized plate bearing 8 setae. Measurements of tarsus I (1 specimen); TL: 185, TH: 30, TL/TH: 6.2.

Gnathosoma: Cheliceral base stout, with conspicuous puncta; blade with about 15 flat teeth. Cheliceral measurements (1 specimen); BL: 109, BH: 58, CL: 66, BL/BH: 1.9, BL/CL: 1.7. Palpus with outer femoral and outer genual setae bearing short paired branches rather than longer single branches; tarsus with 4 inner, 2 outer apical nude setae; tarsala about 13 μ long. Setal counts (1 specimen); femur: 15.5, genu: 10, tibia: 6, tarsus: 9.

Scutum: Tectal setae apical. Crista with several puncta. Basal plate broad; apodeme narrow and elongated; sensillary bases towards posterior of sensillary area. Scutal measurements (1 specimen); ASL: 107, SB: 21, TS: 43, SENS: about 60, ASL/SB: 5.1.

Remarks.—On the single occasion on which this species was reared, one of two larvae reached the nymphal stage. (The nymph was offered collembola eggs but did not eat.

Specimens examined.—One nymph, as follows: KANSAS. *Cheyenne County*: 15 mi. N, 11½ W St. Francis, *Peromyscus maniculatus*, November 1, 1952 (1 nymph, reared DAC).

Genus *Acomatacarus* Ewing

Acomatacarus Ewing, 1942, Jour. Parasit., vol. 28, p. 490 (type *Acomatacarus arizonensis* Ewing).

Diagnosis (nymph).—(1) Body shape oval, not constricted. (2) *Posterior body setae modified, expanded.* (3) Mean ratio TL/TH: about 2.1. (4) *Tarsus I rather pyriform.*

Additional features (numph).—(5) Body size small to medium (about 0.4-0.6 mm. long). (6) Eyes absent or 1/1. (7) With or without long and short body setae intermixed. (8) Sclerotized sternal plate present. (9) *Legs not unusually elongated; branched setae slightly expanded.* (10) Cheliceral blade shearlike or daggerlike. (11) Palpus short, rather small; *some femoral setae expanded, some genual setae expanded;* claw moderate in size; tarsus with about six to eight branched setae and three to five apical nude setae. (12) Hypostome pointed and projecting, or blunt; six to eight apical setae, nude or branched; about ten ventral branched setae. (13) Basis capituli normal to broad and short in shape. (14) Tectum well sclerotized, intermediate in size; tectal setae expanded or not. (15) Crista rodlike, narrow or somewhat broadened. (16) Sensillary area oval to transverse-oval; mean ratio ASL/SB: 3.2-4.5. (17) About ten to fifteen parascutal setae.

Remarks.—Womersley (1945:98) described the reared nymphs of *Acomatacarus australensis* (Hirst), *A. longipes* (Womersley), and *A. nova-queina* (Womersley). He also placed in that genus *Rhyncholophus retentus* Banks, *Dromeothrombium dromus* Womersley, and *Acomatacarus patrius* Womersley, all known only as adults. Their affinities with *Acomatacarus* were established by comparisons with the reared nymphs mentioned above. This action appears to have been well taken. The diversity of forms suggests that eventually some generic reassignments will prove necessary but for the present a broad genus *Acomatacarus* seems advisable.

The descriptions of these species as given by Womersley are generally in agreement with the generic description proposed by the writer. One species, *dromus*, has long unmodified body setae. Womersley reports that all of the species have no accessory palpal claws but instead three or four short spines at the base of the main claw. This observation should be verified.

In addition to the above mentioned species and the two described in this paper, some 35 species of *Acomatacarus* known only from the larval stage have been described.

KEY TO SUBGENERA OF ACOMATACARUS (NYMPHS)

1. Cheliceral blade shearlike. A. (*Acomatacarus*) p. 196
 1'. Cheliceral blade narrow, daggerlike. A. (*Xenacarus*) p. 197

Subgenus *Acomatacarus* Ewing

Acomatacarus, Womersley, 1945, Trans. Roy. Soc. South Australia, vol. 69, p. 98 (*nymph*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 97 (*nymph*).

Diagnosis (nymph).—(10) *Chelicera with blade shearlike*. (11) Palpal tarsus with five apical nude setae. (12) *Hypostome pointed, projecting*, with about eight apical nude setae. (14) Tectal setae not expanded.

Remarks.—These features appear to be the ones of subgeneric importance which characterize A. (*Acomatacarus*) as opposed to A. (*Xenacarus*). The postlarvae described by Womersley appear to fall within the typical subgenus.

Acomatacarus arizonensis Ewing

(Figs. 37, 142, 209)

Acomatacarus arizonensis Ewing, 1942, Jour. Parasit., vol. 28, pp. 490-491 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1236-1238 (*larva*).

Description of nymph.—Body: about 0.4 mm. long, color dull red. Eyes absent. Setae expanded; tips rounded; branches thin and short; most setae short but longer ones (2-3 times longer) scattered among these; posterior setae (longer ones) about 30 μ long. Sternal area with broad plate bearing ten modified setae. Measurements of tarsus I (1 specimen); TH: 36, TL: 75, TL/TH: 2.1.

Gnathosoma: Cheliceral base stout, rather rounded, punctate; blade with about 16 small teeth; apodeme of blade not constricted, and blunt. Cheliceral measurements (1 specimen); BL: 56, BH: 31, CL: 36, BL/BH: 1.8, BL/CL: 1.6. Palpus somewhat stout; outer femoral and outer genual setae slightly expanded; tarsus with 3 inner, 2 outer apical nude setae; tarsala not seen. Setal counts (1 specimen); femur: 9-10, genu: 5-6, tibia: 5, tarsus: 8.

Scutum: Tectal setae apical. Crista rather broad. Sensillary area with apodeme broad; sensillary bases small; basal plate wide. Scutal measurements (1 specimen); ASL: 58, SB: 18, TS: 20, SENS: about 60, ASL/SB: 3.2.

Remarks.—Several additional attempts to rear this species were unsuccessful, possibly due to inadequate moisture control. The species appears to be restricted to arid situations (see Loomis, 1956:1237).

A. arizonensis lacks striking distinctive features; most of the known postlarvae of *Acomatacarus* are clearly congeneric with *arizonensis* (the genotype), on the basis of their descriptions.

In the key given by Womersley (1945:110), *arizonensis* (as nymph) will key out to *dromus* (known only as adult). These species may be separated by the form of the body setae; in *arizonensis* the dorsal body setae are expanded while in *dromus* they are slender.

Specimens examined.—One nymph, as follows: *Arizona*. Cochise County: *Sceloporus jarrovi*, July 8, 1951, taken by H. S. Fitch (1 nymph, reared LJL).

Subgenus *Xenacarus* Greenberg

Xenacarus Greenberg, 1951, Jour. Parasit., vol. 37, p. 525 (type *Acomatacarus* (*Xenacarus*) *plumosus* Greenberg).

Diagnosis (nymph).—(10) *Chelicera* with blade straight, daggerlike. (11) Palpal tarsus with three apical nude setae. (12) *Hypostome* blunt, with about six to eight apical, sparsely-branched setae. (14) Tectal setae somewhat expanded.

Remarks.—Of these features, the blunt hypostome and the straight, daggerlike cheliceral blade appear to be characters of group importance. The expanded tectal setae are of interest. Other species with expanded or modified body setae nevertheless have slender tectal setae.

Acomatacarus plumosus Greenberg

(Figs. 34, 88, 134, 135, 138, 189, 205, 207)

Acomatacarus plumosus Greenberg, 1951, Jour. Parasit., vol. 37, pp. 525-527 (larva); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1240-1241 (larva).

Description of nymph.—Body: About 0.6 mm. long, color white. Eyes 1/1; red in life; about 12 μ in diameter. Setae with body expanded but base of normal size; tips rounded; branches of two types, mostly large and heavy but with small branches interspersed; adjacent setae of similar lengths; posterior setae about 25 μ long. Sternal area with very broad plate bearing about ten modified setae. Measurements of tarsus I (means of 9 specimens); TL: 124.7 ± 2.789 ; TH: 58.2 ± 1.025 , TL TH: 2.13 ± 0.0289 .

Gnathosoma: Chelicera with base rather stout, punctuate; blade with about 12 small flat teeth; apodeme of blade not constricted. Measurements of chelicerae (means of 9 specimens); BL: 60.7 ± 0.928 , BH: 32.9 ± 0.605 , CL: 37.9 ± 0.754 , BL/BH: 1.84 ± 0.041 ,

BL/CL: 1.61 ± 0.0602 . Palpus somewhat stout; outer femoral and outer genual setae expanded; tarsus with 2 inner, one outer apical nude setae; tarsala 8μ long. Setal counts; femur: 10.56 ± 0.448 (8 specimens), genu: 6.8 ± 0.214 (10 specimens), tibia: range 4-5, tarsus: range 6-7.

Scutum: Tectal setae apical; expanded, resembling body setae. Crista narrow. Sensillary area oval; basal plate narrow; apodeme narrow. Scutal measurements (means of 8 specimens); ASL: 104.8 ± 3.98 , SB: 23.7 ± 0.799 , TS: 26.3 ± 2.496 , SENS: about 100, ASL/SB: 4.53 ± 0.1878 .

Remarks.—This species was reared to the nymphal stage on several occasions. Collembola eggs were offered as a food material and the nymphs possibly ate the eggs or the freshly-hatched collembolans; feeding was not observed. It is not certain that they fed at all.

A. plumosus is readily identified by the form of the body setae. In other respects it also differs markedly from *arizonensis*, and is probably generically distinct. The one other species of *Acomatacarus* (*Xenacarus*), *A. brevicalar* Brennan and Jones, is known as larva only.

Specimens examined.—Total 16 nymphs, as follows: KANSAS. Barber County: 4 mi. S Aetna, *Neotoma micropus*, August 22, 1949 (4 nymphs, reared LJL), September 15, 1953 (3 nymphs, reared DAC, idet. by larval skin); $3\frac{1}{2}$ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (8 nymphs, reared LJL); 4 mi. S Aetna, *Peromyscus leucopus*, September 15, 1953 (1 nymph, reared DAC).

Genus *Chatia* Brennan

Chatia Brennan, 1946, Jour. Parasit., vol. 32, p. 132 (type *Chatia setosa* Brennan); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 163 (*nymph*).

Diagnosis (nymph).—(1) Body shape oval, not constricted. (2) Posterior body setae not modified, branched, and ending in long, single, attenuated tips; not expanded. (3) Ratio TL/TH: 2.5. (4) Tarsus I cylindrical.

Additional features (nymph).—(5) Body size medium (about 0.8 mm. long). (6) Eyes 1/1. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) Legs unusually elongated; branched setae not expanded. (10) Cheliceral blade shearlike. (11) Palpus stout, large; claw somewhat elongated; tarsus with about fourteen branched setae and six or seven apical nude setae. (12) Hypostome pointed, projecting; with about eight

apical nude setae and numerous ventral branched setae. (13) Basis capituli of normal shape. (14) Tectum well-sclerotized, large, sagittate in shape; setae elongated, not expanded. (15) *Crista a broad rod, with prominent punctation*. (16) Sensillary area oval; ratio ASL/SB: 5.1. (17) About ten to fifteen parascutal setae.

Remarks.—A few characters for nymphs of *Chatia* were given by Wharton *et al.* (1951:30) and by Audy (1954:163). Most noteworthy are the elongated legs (all longer than the body), the prominent puncta of the crista, and the attenuated tips of the body setae.

Chatia setosa Brennan

(Figs. 16, 92, 93, 141, 190, 210)

Chatia setosa Brennan, 1946, Jour. Parasit., vol. 32, p. 132 (*larva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 163 (*nymph*).

Description of nymph.—Body: About 0.8 mm. long, color not known. Eyes about 23 μ in diameter. Body setae normal, with rather short branches; tips long, single, attenuated; posterior setae about 75 μ long. Sternal area containing nearly square sclerotized plate, bearing about 30 setae. Legs noticeably elongated, all longer than body. Measurements of tarsus I (means of 3 specimens); TL: 266.3 ± 17.37 , TH: 107.0 ± 2.517 , TL/TH: 2.50 ± 0.2082 .

Gnathosoma: Chelicera with base large, stout, punctate; blade with about 35 to 50 small to tiny teeth, apodeme of blade not constricted. Cheliceral measurements (means of 3 specimens); BL: 175.7 ± 1.33 , BH: 75.0 ± 1.15 , CL: 99.0 ± 1.00 , BL/BH: 2.33 ± 0.067 , BL/CL: 1.80 ± 0.0000 . Palpus with setae numerous; tarsala about 13 μ long; tarsus with apical nude setae arranged 1 outer, 5 or 6 inner. Setal counts (means of 3 specimens); femur: 30.43 ± 1.00 , genu: 20.00 ± 1.50 , tibia: range 8-11, tarsus: range 13-18.

Scutum: Crista broadly joined to sensillary area; apodeme large, prominent; sensillary bases at back of sensillary area. Scutal measurements (means of 3 specimens); ASL: 159.7 ± 5.84 , SB: 32.5 ± 0.500 , TS: 85.7 ± 4.63 , SENS: about 120, ASL/SB: 5.10 ± 0.100 .

Remarks.—This is the only species in the genus. The specimens were reared by Dr. James M. Brennan, and were originally loaned to Mr. Louis J. Lipovsky. Dr. Brennan and Mr. Lipovsky have very kindly allowed me to describe them.

Specimens examined.—Total 3 nymphs, as follows: MONTANA, Ravalli County: *Citellus lateralis cinerascens*, field no. AP-22355, May 22, 1946 (2 nymphs, reared by Dr. Brennan); *Tamiasciurus*

hudsonicus richardsoni, field no. AP-21201, November 11, 1944 (1 nymph, reared by Dr. Brennan).

Genus *Hannemania* Oudemans

Hannemania Oudemans, 1911 Ent. Berichten, vol. 3, p. 137 (Type *Heterothrombium hylodeus* Oudemans); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*).

Diagnosis (nymph).—(1) *Body constricted, figure 8-shaped*. (2) Posterior body setae elongated, not expanded, *each ending in hooklike spine*. (3) Mean ratio TL/TH: 2.1-2.5. (4) Tarsus I nearly cylindrical.

Additional features (nymph).—(5) Body size medium to large (about 0.9-1.2 mm.). (6) *Eyes 2/2*. (7) Adjacent body setae of similar lengths. (8) Sternal area sclerotized. (9) Legs not unusually elongated; branched setae not expanded. (10) Cheliceral blade shearlike. (11) Palpus stout, size moderate to large; claw moderate in size; tarsus with about ten to twenty branched setae and five apical nude setae. (12) Hypostome pointed, projecting; with about eight apical nude setae and numerous ventral branched setae. (13) Basis capituli normal to short and broad in shape. (14) *Tectum small*, well-sclerotized; tectal setae elongated, not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; mean ratio ASL/SB: 3.7-4.5. (17) *About fifty parascutal setae*.

Remarks.—Larvae of species of *Hannemania* parasitize only amphibians; they are unique in that they burrow into the skin. The larvae may also be recognized by their peculiar, expanded chelicerae.

Postlarvae are distinct from other leeuwenhoekiiines particularly in characters (1), (2), (6), (14), and (17) as indicated above. Of these, the constricted body (1) is puzzling since this feature is typical of Trombiculinae. Otherwise, *Hannemania* is more closely similar to other leeuwenhoekiiines. Mounted specimens are readily identified by the strong hooklike tips of the posterior body setae.

The genus is widespread in the New World, but has not been recently revised. Of the some fifteen described species, only one was previously known in postlarval stages. Nymphs and adults of *Hannemania hylae* (Ewing) were described by Ewing (1926:266, figs. 3-4). His descriptions and figures are similar to the species described here, in general, but he did not give enough details for specific recognition.

KEY TO SPECIES OF HANNEMANIA (NYMPHS)

- 1. Cheliceral blade rather broad (fig. 19) *multifemorala* p. 203
- 1'. Cheliceral blade narrow (fig. 20) 2
- 2. Generally smaller; mean ASL about 150 μ , range 117-170 μ ;
mean SB about 34 μ , range 21-38 μ ; distance across both eyes
about 40 μ *eltoni* p. 202
- 2'. Generally larger; mean ASL about 218 μ , range 215-220 μ ; mean
SB about 53 μ , range 49-56 μ ; distance across both eyes about
80 μ *dunni* p. 201

Hannemania dunni Sambon

(Fig. 204)

Hannemania dunni Sambon, 1928, Ann. Trop. Med. Parasit., vol. 22, p. 129 (larva); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1246 (larva).

Description of nymph.—Body: About 1.2 mm. long, color red. Eyes red in life, distance across both eyes about 80 μ . Setae thick but not expanded, branches as usual; tip of each a recurved hook-like spine; posterior setae about 70 μ long. Sternal area about square, sclerotized, with about 15 setae. Measurements of tarsus I (1 specimen); TL: 270, TH: 110, TL/TH: 2.5.

Gnathosoma: Basis capituli of normal shape. Cheliceral base of usual shape, with numerous conspicuous puncta; blade shearlike but narrowed, with about 23 small teeth, apodeme of blade not constricted. Cheliceral measurements (means of 3 specimens); BL: 187.3 ± 4.06 , BH: 78.0 ± 3.61 , CL: 105.7 ± 2.73 , BL/BH: 2.37 ± 0.058 , BL/CL: 1.77 ± 0.033 . Palpus of usual shape; tarsala about 18 μ long; tibia without seta at inner tarsal articulation, but with stiff monopectinate seta below accessory claws; tarsus with 4 inner, 1 outer apical nude setae. Setal counts (1 specimen); femur: 45, genu: 31, tibia: range 7-9, tarsus : range 18-19.

Scutum: Tectal setae apical, set in pits. Apodeme large. Scattered puncta present. Scutal measurements (means of 2 specimens); ASL: 217.5 ± 2.50 , SB: 52.5 ± 3.501 , TS: 56.0 ± 0.000 , ASL/SB: 4.15 ± 0.2500 .

Remarks.—This species, like *H. eltoni*, proved easy to culture and as a result more adults were available for study than nymphs. Both nymphs and adults ate collembola eggs.

Hannemania dunni is very similar to *H. eltoni*. The characters used to separate these two as nymphs involve size, *dunni* being much the larger.

Loomis (1956:1246) identifies larvae from which these nymphs

were reared, as *Hannemania dumni* and I accept his identification. However, these larvae are somewhat larger than other *dumni* of Loomis and may be specifically distinct.

Specimens examined.—Total 4 nymphs, as follows: ARKANSAS. *Montgomery County*: *Plethodon caddoensis*, January 26, 1952, taken by H. A. Dundee (4 nymphs, reared DAC).

Hannemania eltoni Sambon

(Figs. 20, 61, 98, 99, 139)

Hannemania eltoni Sambon, 1928, Ann. Trop. Med. Parasit., vol. 22, p. 129 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1243 (*larva*).

Description of nymph.—Resembles *Hannemania dumni*, except as follows:

Body: About 0.9 mm. long. Distance across both eyes about 40 μ . Setae with branches longer; posterior setae about 45 μ long. Measurements of tarsus I (means of 9 specimens); TL: 184.5 \pm 6.01, TH: 86.2 \pm 2.72, TL/TH: 2.14 \pm 0.0503.

Gnathosoma: Basis capituli short, broad. Cheliceral base not heavily punctate; blade with about 14-29 teeth. Cheliceral measurements (means of 9 specimens); BL: 120.0 \pm 5.21, BH: 53.3 \pm 2.69, CL: 74.4 \pm 3.00, BL/BH: 2.33 \pm 0.110, BL/CL: 1.61 \pm 0.035. Palpus with tarsala about 16 μ long. Setal counts; femur: 30.56 \pm 2.17 (8 specimens), genu: 18.45 \pm 0.575 (10 specimens), tibia: range 5-8, tarsus: range 10-16.

Scutum: Measurements (means of 9 specimens); ASL: 149.6 \pm 5.68, SB: 33.6 \pm 1.733, TS: 33.5 \pm 0.707, SENS: about 100-150, ASL/SB: 4.5 \pm 0.247.

Remarks.—This species is readily cultured. Both nymphs and adults eat collembola eggs.

Loomis (1956:1243) discusses the application of the name *eltoni* to larvae from which these nymphs were reared.

Specimens examined.—Total 24 nymphs, as follows: TEXAS. *Bexar County*: Camp Bullis, *Rana pipiens*, April 25, 1954 (8 nymphs, reared RBL). KANSAS. *Seward County*: 12 mi. NE Liberal, *Rana pipiens*, September 9-10, 1948 (11 nymphs, reared LJL). *Cheyenne County*: 4 mi. N St. Francis, *Rana pipiens*, July 22, 1948 (3 nymphs, reared LJL). *Johnson County*: Sunflower, *Acris gryllus*, March 29, 1949 (2 nymphs, reared LJL).

Hannemania multifemorala Loomis

(Figs. 19, 178)

Hannemania multifemorala Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1247 (larva).

Description of nymph.—Resembles *Hannemania dunni* except as follows:

Body: About 1.1 mm. long. Eyes present but indistinct. Posterior body setae about 40 μ long. Measurements of tarsus I (1 specimen); TL: 170, TH: 75, TL/TH: 2.3.

Gnathosoma: Cheliceral base not heavily punctate; blade rather broad, upper margin straight, with about 16 small teeth. Cheliceral measurements (means of 2 specimens); BL: 110.5 ± 10.5 , BH: 53.3 ± 4.5 , CL: 60.5 ± 9.50 , BL/BH: 2.05 ± 0.05 , BL/CL: 1.85 ± 0.150 . Palpus with tarsala about 11 μ long. Setal counts (1 specimen); genu: 25, tarsus: 13 (other segments obscured).

Scutum: Measurements (1 specimen); ASL: 118, SB: 32, ASL/SB: 3.7.

Remarks.—The presence of this species, which occurs with *H. eltoni*, was not detected until the latter part of our work. It does not culture well, and cultures of *Hannemania* from Kansas appear to be pure *eltoni*. Possibly culture conditions favorable to *eltoni* eliminate *multifemorala*.

Specimens examined.—Total 3 nymphs, as follows: TEXAS. *Erath County*: Stephenville State Park, *Microhyala olivacea*, April, 1952, taken by H. S. Fitch (1 nymph, reared DAC). NEBRASKA. *Richardson County*: $\frac{1}{2}$ mi. W Verdon, *Rana pipiens*, August 20, 1948 (2 nymphs, reared LJL).

Genus *Whartonia* Ewing

Whartonia Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 102 (type *Hannemania nudosetosa* Wharton); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 164 (nymph).

Diagnosis (nymph).—(1) Body shape oval, not constricted. (2) Posterior body setae modified, leaflike. (3) Ratio TL/TH: 2.4. (4) Tarsus I rather pyriform.

Additional features (nymph).—(5) Body size medium (0.8 mm. long). (6) Eyes absent. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) Legs not unusually elongated; branched setae slightly expanded. (10) Chelic-

eral blade narrowed, nearly shearlike. (11) Palpus stout, moderate in size; *trochanter short, broad*; *some femoral, some genual setae expanded*; claw moderate in size; tarsus with seven branched setae and five apical nude setae. (12) *Hypostome blunt*, with six to eight apical setae with reduced branching; about ten branched, slightly expanded ventral setae. (13) Basis capituli of normal shape. (14) Tectum large, well-sclerotized, saggitate in shape; *tectal setae forked*, not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; ratio ASL/SB: 3.6. (17) About ten to fifteen parascutal setae.

Remarks.—The above characterization is based upon *Acomatacarus senase* Greenberg, which Loomis (1956:1241) transferred to *Whartonia*. Although this species does fit the generic diagnosis given by Wharton and Fuller (1952:104) for larvae, possibly it is not congeneric with *Whartonia nudosetosa*, the genotype.

Morphologically *Whartonia senase* is quite similar to *Acomatacarus*. Some features appear to be of group importance, including the narrowed cheliceral blade (10), the short palpal trochanter (11), the blunt hypostome (12) and the forked tectal setae (14). The leaflike modification of the posterior body setae is the most obvious character for recognition.

Besides *W. senase*, four species of *Whartonia* have been described and while some have evidently been reared, the nymphal descriptions have not been published.

Whartonia senase (Greenberg)

(Figs. 36, 60, 94, 95, 143, 182, 187, 234)

Acomatacarus senase Greenberg, 1952, Ann. Ent. Soc. America, vol. 45, p. 484 (larva).

Whartonia senase, Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1242 (larva).

Description of nymph.—Body: About 0.8 mm. long, color not known. Setae modified as leaflike structures; central stem of each evident but bearing two lateral flanges with sclerotized margins and weblike surfaces; margins of flanges irregular; central stem with small branches; posterior setae about 25 μ long. Sternal area containing broad sclerotized plate, with 8 expanded setae. Measurements of tarsus I (1 specimen) TL: 141, TH: 60, TL/TH: 2.4.

Gnathosoma: Cheliceral base stout, punctate, area of articulation with basis capituli slightly shortened; blade rather narrow but curved, about 10 tiny teeth on apical portion, apodeme of blade not constricted. Cheliceral measurements (1 specimen); BL: 60, BH:

34, CL: 38, BL/BH: 1.8, BL/CL: 1.6. Palpus with dorsal femoral and dorsal genual setae slightly expanded; claw slender; tarsala about $8\ \mu$ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (1 specimen): femur: 12, genu: 10.5, tibia: range 4-5, tarsus, 7.

Scutum: Tectum with margin conspicuously sclerotized; setae forked at about half their length. Crista broadened gradually towards posterior. Apodeme short, blunt. Scutal measurements (1 specimen); ASL: 107, SB: 30, TS: 25, SENS: (obscured), ASL/SB: 3.6.

Specimens examined.—Total one, as follows: KANSAS. Barber County: $3\frac{1}{2}$ mi. S, 1 mi. W Aetna, *Myotis velifer*, April 10, 1949 (1 nymph, reared L.J.L.).

SUBFAMILY TROMBICULINAE Ewing

Ewing, 1929, Manual of External Parasites, p. 22.

Diagnosis (nymph).—Body constricted, figure 8-shaped. Tectum with one or no setae. Sensilla variable, with at least short basal branches (except *Blankaartia*). Anus obviously divided into two shoelike portions. Setae on palpal genu more numerous than those on palpal femur, or about the same number on these segments.

Additional features (nymph).—Eyes usually absent; when present 1/1 and either anterior to or adjacent to sensillary area. Sternum variable, rarely open behind or with precoxal plates of coxae I; usually closed behind by a crossbar connecting coxae II. Scutum with tectal margin variable; mean ratio ASL/SB: about 1.0-3.2; bulla usually prominent, sometimes small; lateral keels present; carina usually present; ridges often present in sensillary area. Gnathosoma with cheliceral base elongated to unusually elongated (mean ratio BL/BH: 1.9-4.0); articulation of cheliceral base with basis capituli usually ventral but sometimes terminal; posterior tip of cheliceral base elevated or depressed. Palpus usually with two accessory claws, rarely only one or more than two. Pharynx usually inconspicuous but sometimes marked with a reticulate pattern.

Diagnosis (larva).—(Modified from Wharton and Fuller, 1952: 41). Leg I with seven segments, legs II and III with six or seven segments; anterior, median projection of scutum absent; antero-medial scutal seta present or absent; paired submedian scutal setae absent.

Included genera.—Known from both larvae and postlarvae: *Ascoshöngastia* Ewing, *Blankaartia* Oudemans, *Cheladonta* Lipov-

sky *et al.*, *Doloisia* Oudemans, *Euschöngastia* Ewing, *Euschöngastoides* Loomis, *Guntherana* Womersley and Heaslip, *Heaslipia* Ewing, *Neoschöngastia* Ewing, *Pseudoschöngastia* Lipovsky, *Schöngastia* Oudemans, *Schoutedenichia* Jadin and Vercammen-Grandjean, *Speleocola* Lipovsky, *Trombicula* Berlese, *Walchia* Ewing, and *Walchiella* Fuller. Known only from larvae: *Anominalaspis* Brennan, *Babiangia* Southcott, *Endotrombicula* Ewing, *Gahrliopia* Oudemans, *Gateria* Ewing, *Giroudia* Vercammen-Grandjean, *Mackiena* Traub and Evans, *Myotrombicula* Womersley and Heaslip, *Novotrombicula* Womersley and Kohls, *Oenoschöngastia* Womersley and Kohls, *Riedlinia* Oudemans, *Sauracarella* Lawrence, *Schöngastiella* Hirst, *Tecomatlana* Hoffmann and *Womersia* Wharton. Known only from adults: *Ipotrombicula* Womersley and *Speotrombicula* Ewing.

Remarks.—Of the sixteen genera known only as larvae, nine are monotypic; only two of sixteen genera known from both larvae and postlarvae are monotypic. The two genera known only as adults are monotypic and are obviously based on single characters.

The subfamily Trombiculinae as represented here includes genera formerly placed in the subfamily Walchiinae (= Gahrliopiinae).

As postlarvae the genera are divisible into two groups. The genera *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia* (and probably *Schoutedenichia*) share the following features: Cheliceral base with posterior tip elevated, area of articulation with basis capituli ventral; hypostome short, blunt, with about twenty short apical nude or nearly nude setae; pharynx marked with a reticulate pattern; scutum short and broad, mean ratio ASL/SB: about 1.2-1.7.

Remaining genera have the cheliceral base with posterior tip depressed, area of articulation with basis capituli ventral; hypostome elongated, tip usually pointed but sometimes blunt, with about eight apical nude setae; pharynx not marked with a reticulate pattern; scutum longer, mean ratio ASL/SB: 2.0 or greater (except *Guntherana* and *Doloisia*). However, the use of formal names for these groups would be premature.

Species studied by the writer are members of the genera *Blankaartia*, *Cheladonta*, *Euschöngastia*, *Euschöngastoides*, *Neoschöngastia*, *Pseudoschöngastia*, *Speleocola*, *Trombicula*, and *Walchia*. Descriptions of other postlarvae are sufficiently complete so that the remaining genera can be keyed out, except for *Ascoshöngastia* and *Walchiella*, and several subgenera. In the following discussions the genera seen by the writer will be presented first, and those not seen will follow.

KEY TO GENERA OF TROMBICULINAE (NYPHS)

1. Leg I with a pair of distally trifurcate claws . . . *Speotrombicula** p. 274
- 1'. Leg I with a pair of distally undivided claws 2
2. Scutum with a branched body seta at the base of the crista, in the sensillary area *Ipotrombicula** p. 273
- 2'. Scutum without a body seta in the sensillary area 3
3. Precoxal plates of coxa I present and separated, not fused in the midline to form a longitudinally divided sternum 4
- 3'. Precoxal plates of coxa I usually absent; if present they are fused in the midline to form a longitudinally divided sternum 6
4. Long and short body setae intermixed (American species with extremely elongated palpal claws) *Neoschöngastia* p. 231
- 4'. Adjacent body setae of similar lengths; palpal claws not unusually elongated 5
5. Sensillary area narrower (ratio ASL/SB: about 2 in nymphs)
*Schöngastia** p. 274
- 5'. Sensillary area wide (ratio ASL/SB: about 1 in nymphs)
*Guntherana** p. 272
6. Tarsus I with a stumplike process on dorsoapical margin 7
- 6'. Tarsus I without a stumplike process on dorsoapical margin 8
7. Tectal seta absent *Walchia* p. 268
- 7'. Tectal seta present *Schoutedenicchia** p. 274
8. Cheliceral base unusually elongated distally (ratio BL/BH: about 4.0 in nymphs); cheliceral blades rather short, semilunar; palpal trochanter elongated *Cheladonta* p. 211
- 8'. Cheliceral base only rarely unusually elongated (ratio BL/BH: up to 3.6 in nymphs); cheliceral blades longer, shearlike; palpal trochanter not elongated 9
9. Hypostome short, blunt, with about twenty short apical nude or nearly nude setae; pharynx marked with a reticulate pattern 10
- 9'. Hypostome long, pointed, with about eight longer apical nude setae; pharynx indistinct 11
10. Tectal margin without serrations; sensilla stiff, thick to subclavate; mean ratio ASL/SB: about 1.7 *Pseudoschöngastia* p. 235
- 10'. Tectal margin with serrations; sensilla almost flagelliform, flexible; mean ratio ASL/SB: about 1.3 *Euschöngastoides* p. 226
11. Eyes present in front of and separated from sensillary area; sensilla completely nude *Blankartia* p. 208
- 11'. Eyes usually absent; when present, at the sides of and adjacent to sensillary area; sensilla with at least short basal branches 12
12. Tectal margin without teeth or serrations 13
- 12'. Tectal margin with teeth or serrations 14
13. Tectum large or small but hyaline, not developed into a sclerotized "nose" *Euschöngastia* p. 215
- 13'. Tectum large, an elongated triangular cone, not hyaline, developed into a conspicuous "nose" *Heaslipia** p. 273
14. Posterior body setae short and with compound branching
Speleocola p. 238

* Specimens were not seen by the writer.

14. Posterior body setae short or long but never with compound branching 15
 15. Sensillary area narrow; mean ratio ASL/SB: 1.9-2.7 *Trombicula* p. 258
 15'. Sensillary area wide; mean ratio ASL/SB: 0.7-1.2 *Dolosisia** p. 271

Genus *Blankaartia* Oudemans

- Blankaartia* Oudemans, 1911, Ent. Bcr., vol. 3, p. 123 (type *Trombidium niloticum* Trägårdh, 1904) (*adult*).
Trombicula (*Blankaartia*), Fuller and Wharton, 1951, Psyche, vol. 58, p. 87; Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 29; Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 42.
Trombicula (*Trägårdhula*) Berlese, 1912, Redia, vol. 8, p. 4 (type *Trombidium niloticum* Trägårdh, 1904).
Trägårdhula, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 83; Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 114 (*post-larvae*).
Pentagonella Thor, 1936, Zool. Anz., vol. 114, p. 30 (type *Trombidium ardeae* Trägårdh, 1904).
Trombicula (*Megatrombicula*) Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 432 (type *Trombicula alleei* Ewing, 1926).

Diagnosis (nymph).—(1) *Eyes* 1/1, separated from sensillary area. (2) Precoxal plates absent. (3) Body setae branched, not expanded, no compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting, with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum triangular, somewhat sclerotized, with smooth margin; with a single tectal seta. (11) Sensillary area triangular; mean ratio ASL/SB: 2.9-3.2. (12) Without branched body seta in sensillary area. (13) Sensilla flagelliform, long, entirely nude.

Additional features (nymph).—(14) Body size medium (about 0.8-0.9 mm. long), of usual shape. (15) Sternum pentagonal, closed behind. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; base with posterior tip depressed. (18) Palpus stout, large; distal portion of tibia unusually elongated; palpal claw short, slightly curved; two to seven accessory claws; tarsus with about seven branched setae and four or five apical nude setae. (19) Hypostome with about twenty ventral branched setae. (20) Basis capituli of usual shape. (21) Crista narrow, elongated. (22) Sensillary area with basal plate of two bandlike halves; bulla elongated anteriorly; carina apparently absent; sensillary bases placed well lateral; anterior, lateral, and posterior ridges somewhat weak; ridges medial to sensillary bases present; apodeme normal. (23) About thirty parascutal setae.

* Specimens were not seen by the writer.

Remarks.—Fuller and Wharton (1951:85) have discussed the proper name for this group. I follow them in considering *Pentagonella* and *Megatrombicula* as synonyms. Womersley has persisted in using the name *Trägårdhula*.

Previously *Blankaartia* has been accommodated as a subgenus of *Trombicula* (except by Womersley, who uses generic status). The reasons appear to have been twofold; while *Blankaartia* postlarvae appear distinct, little is known of *Trombicula* postlarvae, and *Blankaartia* larvae are very similar to certain *Trombicula* larvae. This situation has not changed, except that more *Trombicula* postlarvae have become known.

I have decided to follow Womersley in giving generic status to this group. Nymphs of *Blankaartia* appear related to those of *Trombicula* but are amply distinct. The larvae are more closely similar but can apparently be separated (by keys to subgenera of *Trombicula* as given by several authors).

Distinctive features of *Blankaartia* appear to be primitive ones as well. The position of the eyes, the entirely nude sensilla, and the smooth tectal margin are leeuwenhoekine characters. The numerous accessory claws are also found in the Trombidiidae. The scutum, while triangular, is distinct from that of *Trombicula* in possessing an elongated bulla and lacking a carina.

The diagnosis given above is based upon the two species *B. alleei* and *B. velascoi*. Additional postlarvae are known: *B. nilotica* and *B. peruviana* are known only as adults; postlarvae of *B. acuscutellaris* and *B. attenuata* have also been described. A single species, *B. ardeae*, is known only as the larva. Descriptions of known postlarvae may be found in Womersley, 1952, pages 314-323.

The generic diagnosis given above differs from descriptions of Womersley in an important respect. Womersley describes the tectum ("epistome") as bearing "fine denticulations." In specimens (including adults) of *B. alleei*, *B. attenuata* (adults only), and *B. velascoi*, examined by me, the tectal margin appears smooth. Womersley's drawing of *B. velascoi* shows the tectal margin as nearly smooth. The tectal margins of *B. acuscutellaris* and *B. nilotica* are illustrated as possessing more marked teeth. This character requires confirmation.

Womersley includes in *Trägårdhula* (= *Blankaartia*) the species *Trombicula japonica* (Tanaka), on the basis of Tanaka's description of eyes anterior to the sensillary area. However, Sasa (1953: 423) describes the nymph as lacking eyes, and places it in *Trombicula* (*Neotrombicula*), as do Philip and Fuller (1950:50). It is

evident that Womersley is dealing with a different form than is Sasa. I follow Philip and Fuller, and Sasa, and place *japonica* in *Trombicula* (*Neotrombicula*).

Besides *B. alleei* and *B. velascoi*, only *B. acuscutellaris* is known also as a nymph. Womersley (1952:317) describes the nymph of *acuscutellaris* but gives no characters to separate it from *alleei*. Michener (1946:434) presents a key which separates nymphs of *alleei* and *velascoi*.

Blankaartia alleei (Ewing) *New Combination*

(Figs. 22, 63, 171, 172, 208)

Trombicula alleei Ewing, 1926, Ent. News, vol. 37, p. 111 (*adult*).

Trombicula (*Megatrombicula*) *alleei*, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 434 (*larva, nymph, adult*).

Trügårdhula alleei, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 89 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 319 (*postlarvae*).

Trombicula (*Blankaartia*) *alleei*, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 43.

Description of nymph.—Body: About 0.9 mm. long, color red. Eyes about 39 μ in diameter, color not known. Body setae normal, tips simple; posterior setae about 50 μ long. Sternum with about 10 setae. Measurements of tarsus I (1 specimen); TL: 224, TH: 117, TL/TH: 1.9.

Gnathosoma: Cheliceral base elongated, punctate; blade elongated but shearlike, nearly devoid of teeth (two tiny teeth present on one chela of single specimen). Cheliceral measurements (1 specimen); BL: 170, BH: 68, CL: 104, BL/BH: 2.5, BL/CL: 1.61. Palpus with dorsal femoral and genual setae with reduced branching, some nude; tibia with stalklike distal elongation bearing stout claw, setae nude, 3 accessory claws on small dorsal flange; tarsala not seen; tarsus with but 5 branched setae with reduced branching, 4 apical nude setae, arranged 2 inner, 2 outer. Setal counts (1 specimen); femur (obscured), genu: 14, tibia: 9, tarsus: 5.

Scutum: Lateral keels not seen. Crista very narrow. Sensillary area triangular but elongated anteriorly (apex of triangle long); bands of basal plate narrow; bulla prominent. Scutal measurements (1 specimen); ASL: 205, SB: 70, TS (obscured), SENS (obscured), ASL/SB: 2.9.

Remarks.—This description is based upon a single specimen reared by Dr. C. D. Michener.

Specimens examined.—One nymph, as follows: PANAMA. *Colón Province*: Santa Rosa, *Myiozetetes cajonensis*, November 11, 1945 (1 nymph, reared by C. D. Michener).

Blankaartia velascoi (Boshell and Kerr), *New Combination*

(Figs. 148, 169, 170, 206)

Trombicula velascoi Boshell and Kerr, 1942, Rev. Acad. Colombiana Cien. Exact., Fisico-Quim. Y Nat., vol. 5, p. 113 (*adult*).*Trombicula* (*Megatrombicula*) *velascoi*, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 438 (*larva, nymph, adult*).*Trägårdhula velascoi*, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 89 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 321 (*postlarvae*).*Trombicula* (*Blankaartia*) *velascoi*, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 44.*Description of nymph.*—Resembles *B. alleei* except as follows:

Body: About 0.8 mm. long, color red. Eyes about 32 μ in diameter. Posterior body setae longer, about 90 μ long; branches short; tips simple, attenuated. Measurements of tarsus I (means of 4 specimens); TL: 208.0 ± 4.97 , TH: 80.5 ± 2.06 , TL/TH: 2.58 ± 0.0855 .

Gnathosoma: Cheliceral blade with 21-30 small teeth (but one specimen without teeth). Cheliceral measurements (means of 3 specimens); BL: 165.3 ± 3.33 , BH: 54.0 ± 0.00 , CL: 88.2 ± 4.13 , BL/BH: 3.0 ± 0.00 , BL/CL: 1.97 ± 1.14 . Palpal tibia with setae showing reduced branching; 4 to 7 accessory claws; tarsala about 13 μ long; tarsus with 5 apical nude setae arranged 3 inner, 2 outer. Setal counts (means of 3 specimens); femur: 8.17 ± 1.833 , genu: 17.3 ± 2.892 , tibia: range 4-7, tarsus: range 6-9.

Scutum: Measurements (means of 4 specimens); ASL: 155.8 ± 2.531 , SB: 48.3 ± 1.0308 , TS: 56 (1 specimen), SENS: about 160, ASL/SB: 3.23 ± 0.0408 .

Specimens examined.—Total 6 nymphs, as follows: PANAMA. Canal Zone: Juan Mina, *Myiozetetes similis*, October 3, 1945 (4 nymphs, reared by C. D. Michener); October 30, 1945 (1 nymph, reared by C. D. Michener). Colón Province: Gatuneillo, *Saltator*, October 30, 1945 (1 nymph, reared by C. D. Michener).

This material, as well as that of *B. alleei*, was kindly lent by Dr. W. V. Gertsch of the American Museum of Natural History.

Genus *Cheladonta* Lipovsky, Crossley and Loomis

Cheladonta Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, pp. 137-139 (type *Cheladonta micheneri* Lipovsky, Crossley and Loomis) (*larva*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae slightly expanded, branched, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical

stumplike process. (6) *Cheliceral base unusually elongated* (mean ratio BL/BH: about 4.0), *blade curved, semilunar-shaped*. (7) *Palpal trochanter elongated*. (8) Hypostome unusually elongated, pointed; with about eight short apical nude setae. (9) Pharynx indistinct. (10) Tectum nearly square, *hyaline*, with or without short teeth on margin, with one tectal seta. (11) *Sensillary area nearly reniform*; mean ratio ASL/SB: about 2.1. (12) Without branched body seta in sensillary area. (13) Sensilla straight to subclavate, branches variable.

Additional features (nymph).—(14) Body size medium (about 0.6-0.7 mm. long), elongated. (15) Sternum roughly triangular, closed behind. (16) *Tarsus I rounded*. (17) Articulating area of cheliceral base with basis capituli ventral, small; base with posterior tip depressed. (18) Palpus somewhat elongated; size moderate; distal portion of tibia not unusually elongated; claw moderate in size, slightly curved; two accessory claws; tarsus with about nine branched setae and one apical nude seta. (19) Hypostome with about ten to twenty ventral setae, *nude or nearly so*. (20) Basis capituli of usual shape. (21) Crista not narrowed, rodlike. (22) Sensillary area with basal plate of two rather broad bands; bulla reduced in size; carina absent; sensillary bases rather small, placed well forward; anterior, lateral, and posterior ridges present but no ridges medial to sensillary bases; *apodeme broad and prominent*. (23) About ten parascutal setae.

Remarks.—The genus *Cheladonta* was erected for the species *C. micheneri*, *C. crossi*, and *C. ouachitensis* from the United States, and *Neoschöngastia ikaoensis* from Japan and Korea. The foregoing diagnosis is based upon nymphs of *micheneri* and *ouachitensis*, and Sasa's (1953:426) description of the nymph of *ikaoensis*. Sasa illustrates no teeth on the tectal margin and states that the tectum is "without conspicuous denticles along anterior margin." Otherwise, his description agrees closely with the American species.

The characters distinctive for *Cheladonta* appear to be (6), (7), (16), (19), the shape of the sensillary area under (11), and the broad scutal apodeme under (22). In combination these characters indicate very distinctive forms; *Cheladonta* postlarvae are immediately recognized as such.

Larvae of *Cheladonta* seem close to *Euschöngastia* or *Neoschöngastia* but possess a key character in the ventral serrations on the cheliceral blade. In contrast, postlarvae appear far removed from other genera. The general appearance of the scutum suggests that

of *Neoschöngastia*, and indeed these two may be closely related. Vercammen-Grandjean (in correspondence) indicates rather close similarities between larvae of *Cheladonta* and larvae of certain species of *Schoutedenichia*; however, postlarvae of these two genera are markedly different.

KEY TO SPECIES OF CHELADONTA (NYMPHS)

- 1. Sensilla subclavate, greatest width near apex; cheliceral blade with teeth large, conspicuous *micheneri* p. 213
- 1'. Sensilla slightly expanded but greatest width in midregion, tapered distally; cheliceral blade with teeth small to tiny 2
- 2. Tectal margin with obvious teeth *ouachitensis* p. 214
- 2'. Tectal margin without obvious teeth *ikaoensis*.

(See remarks on *Cheladonta*, p. 212.)

Cheladonta micheneri Lipovsky, Crossley and Loomis

(Figs. 42, 43, 85, 183, 184, 195, 196)

Cheladonta micheneri Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, p. 137 (larva).

Description of nymph.—Body: About 0.7 mm. long, color orange to white. Setae short, somewhat expanded, tips rounded; branches short and fine; posterior setae about 15 μ long. Sternal area roughly triangular in shape, distinctive; usually closed behind, occasionally with a trace of longitudinal division; with about 8 setae. Legs appear shortened. Measurements of tarsus I (means of 9 specimens); TL: 111.1 ± 2.010 , TH: 72.2 ± 1.847 , TL/TH: 1.56 ± 0.0294 .

Gnathosoma: Cheliceral base peculiarly elongated, somewhat broadened near proximal end but tapering to apex; puncta few; blade short, semilunar, with about 11 teeth, mostly large and conspicuous; apodeme of blade strongly constricted. Cheliceral measurements (means of 8 specimens); BL: 121.3 ± 3.21 , BH: 30.4 ± 0.460 , CL: 34.0 ± 1.02 , BL/BH: 4.0 ± 0.139 , BL/CL: 3.58 ± 0.084 . Palpi rather distinctive in appearance, because of elongated trochanters and genu wider than long; tarsala about 11 μ long; tarsus with apical nude seta on inner surface. Setal counts (means of 8 specimens); femur: 4.44 ± 0.333 , genu: 8.25 ± 0.3134 , tibia: range 4-6, tarsus: range 8-10.

Scutum: Sensillary area nearly reiform but anterior projection present; broad bands of basal plate well separated; apodeme often with irregular markings, furcate at posterior tip; bulla small, triangular; sensilla subclavate with short fine branches which lengthen towards tip. Scutal measurements (means of 9 specimens); ASL: 75.1 ± 1.67 , SB: 35.4 ± 1.001 , TS: 35.3 ± 0.833 , SENS: about 70, ASL/SB: 2.14 ± 0.0377 .

Remarks.—In culture, nymphs of *C. micheneri* ate active stages of collembolans and refused collembola eggs. As larvae they are rarely abundant upon hosts and large numbers were not available for culture purposes.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. *Barber County*: 1 mi. W, 4½ mi. S. Aetna, *Cynomys ludovicianus*, July 27, 1952 (3 nymphs, reared DAC). *Douglas County*: 3 mi. W. Lawrence, *Sylvilagus floridanus*, November 12, 1949 (2 nymphs, reared LJL); Lawrence, *Neotoma floridana* nest, February 20, 1950 (4 nymphs, reared LJL). *Jefferson County*: ½ mi. E. 5½ mi. N Lawrence, *Peromyscus leucopus*, January 26, 1952 (1 nymph, reared DAC). *Norris County*: 2 mi. S Council Grove, *Peromyscus maniculatus*, May 31, 1950 (1 nymph, reared LJL).

Cheladonta ouachitensis Lipovsky, Crossley and Loomis

(Figs. 10, 44, 155, 200, 221)

Cheladonta ouachitensis Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, p. 139 (*larva*).

Description of nymph.—Resembles *C. micheneri* except as follows:

Body: About 0.6 mm. long, color not known. Posterior body setae about 20 μ long. Measurements of tarsus I (means of 3 specimens); TL: 108.7 ± 2.404 , TH: 68.0 ± 2.517 , TL/TH: 1.60 ± 0.0578 .

Gnathosoma: Cheliceral blade with about 13 small or tiny teeth. Cheliceral measurements (means of 3 specimens); BL: 109.0 ± 2.64 , BH: 27.3 ± 1.333 , CL: 30.0 ± 1.15 , BL/BH: 4.0 ± 0.116 , BL/CL: 3.67 ± 0.1333 . Palpus with tarsala about 8 μ long. Setal counts; femur (2 specimens): 3.5 ± 0.0000 , genu (3 specimens): $7:83 \pm 0.3342$, tibia: range 5-6, tarsus: range 6-8.

Scutum: Sensilla slightly expanded in midregion but tapered distally, not subclavate; distal branches rather long. Scutal measurements (3 specimens); ASL: (not obtainable), SB: 31.6 ± 1.886 , TS: 40.3 ± 4.19 , SENS: about 80, ASL/SB: (not obtainable).

Remarks.—These nymphs were reared in a culture of *Trombicula* (*Neotrombicula*). Re-examination of records showed that larvae of *C. ouachitensis* were also taken from the host; there is little doubt that these nymphs are *ouachitensis*.

This species differs from *C. micheneri* in having smaller, more numerous cheliceral teeth and in the nature of the sensilla. Judging from Sasa's description (1953:426), *C. ouachitensis* is very similar to *C. ikaoensis*.

Specimens examined.—Total 3 nymphs, as follows: ARKANSAS. *Polk County*: 2 mi. NE Mena, *Cryptotis parva*, March 3, 1951 (3 nymphs, reared LJL).

Genus *Euschöngastia* Ewing

Euschöngastia Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 293 (type *Schöngastia sciuricola* Ewing) (= *Euschöngastia americana* Ewing) (*larva*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, variable; tips of posterior setae often with tiny branches, *sometimes compound*; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting; with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum triangular, *hyaline, with margin smooth*; with one tectal seta. (11) Sensillary area triangular to transverse-oval in shape; mean ratio ASL/SB: 2.1-2.7. (12) Without branched body seta in sensillary area. (13) Sensilla thick, somewhat straight but not subclavate; branches short.

Additional features (nymph).—(14) Body size small to large (0.4-1.0 mm. long), of usual shape. (15) Sternum closed behind, roughly pentagonal to elongated in shape. (16) Tarsus I usually elongated, sometimes nearly rounded. (17) Articulating area of cheliceral base with basis capituli ventral; base with posterior tip depressed. (18) Palpus usually stout, moderate in size, slightly curved; two accessory claws; tarsus with about nine branched setae and four or five apical nude setae. (19) Hypostome with about ten to twenty ventral branched setae. (20) Basis capituli of usual shape, rarely broadened. (21) Crista a narrow rod. (22) Sensillary area with basal plate of two halves; bulla present, sometimes reduced; carina present; sensillary bases placed well lateral; anterior, lateral, and posterior ridges present but often weak; ridges medial to sensillary bases weak; *toothlike projections often present at front angles of sensillary area*; apodeme usually reduced. (23) About eight to fourteen parascutal setae.

Remarks.—This description is based entirely on the species studied by the writer. Other postlarvae have been described. *Schöngastia samoensis* Womersley and *Microtrombidium westralensis* Womersley, both known only as adults, were placed in *Schöngastia* (*Ascoshöngastia*) (= *Euschöngastia*) by Womersley (1952:

423, 383). Also, Womersley described reared nymphs of *Neoschöngastia lanius* Radford, *Schöngastia audyi* Womersley, *N. kohlsi* Radford, *N. mutabilis* Gater, and *S. nadchatrami* Womersley and placed them in *Schöngastia* (*Ascoshöngastia*). Wharton (1946: 159, 162) gives excellent descriptions of the nymph and adult of *Euschöngastia indica* (Hirst). More recently, Domrow (1955:57, 130) has described the nymphs of *Euschöngastia smithi* (Womersley) and *E. perameles* (Womersley). *Trombicula algerica* Andre, known only as adult, was placed in *Euschöngastia* by Wharton and Fuller (1952:73).

The species known only as adult could as well be accommodated in *Trombicula* as in *Euschöngastia* but their final placement will require more careful descriptions. The species known as both larva and nymph must be more carefully considered.

The only useful character for separating nymphs of *Euschöngastia* from those of *Trombicula* is the nature of the tectum. In *Euschöngastia*, the tectal margin is smooth; in *Trombicula*, the tectal margin has serrations or teeth. In the larval stage a single easily discernible character separates these two genera; *Euschöngastia* has expanded sensilla while *Trombicula* has flagelliform sensilla. Otherwise, the two genera appear similar in both stages. The nymphs of species of *Euschöngastia* as described by Domrow, Wharton, and Womersley all possess serrations on the tectal margin and thus in that key couplet would fall into *Trombicula*. The larvae, however, have expanded sensilla and so would be placed in *Euschöngastia*.

Three of these nymphs, *Euschöngastia indica*, *E. perameles*, and *E. smithi*, would apparently key out to *Euschöngastoides* rather than *Trombicula* or *Euschöngastia*; these species are further discussed under *Euschöngastoides*. The remainder, as described by Womersley, would seemingly key to *Trombicula*. In the illustrations of these species, the tectum is shown as rounded and with fine serrations. Possibly these are in reality absent. Also, Womersley's nymphs are Asiatic while mine are American; possibly there are real group differences between them.

The genus *Euschöngastia* contains a broad assemblage of species and is long overdue for revision and probable recognition of other genera for some species groups. Also, its relations with *Trombicula* must be critically surveyed. Any generic separation based upon a single character is likely to be artificial.

KEY TO SPECIES OF EUSCHÖNGASTIA (NYMPHS)

1. Posterior body setae ending in single long, fine, attenuated tips, never with minute branches near tips *pipistrelli* p. 222
- 1'. Posterior body setae ending in one or (usually) more small or minute branches 2
2. Sensilla with apical portions nude and attenuated, or with short branches very sparse on apical portions 3
- 2'. Sensilla with short branches along entire length 4
3. Sternal area elongated-rectangular *jonesi* p. 220
- 3'. Sternal area nearly pentagonal, not elongated posteriorly, *trigenuala* p. 225
4. One or two rather inconspicuous toothlike projections on anterior margin of sensillary area directly in front of sensillary bases 5
- 4'. Three or four prominent, broad toothlike projections arising from most of anterior margin of sensillary area 7
5. Larger species, ASL about 120 μ , TS about 50 μ , BL about 135 μ *setosa* p. 223
- 5'. Smaller species; ASL about 80-90 μ , TS about 25-30 μ , BL about 100 μ 6
6. Posterior body setae ending in blunt tips with one or two short, minute, thick branches *cynomyicola* p. 218
- 6'. Posterior body setae each ending in attenuated tip divided into two to four short, attenuate branches *cricticola* p. 217
7. Tips of posterior body setae slightly enlarged and ending in numerous short minute compound branches; one (rarely two) lateral branch at each tip characteristically enlarged and prominent
peromyisci p. 221
- 7'. Tips of posterior body setae not enlarged, ending in two or three short, often compound branches; without such a modified lateral branch at tips *diversa* p. 219

Euschöngastia cricticola Brennan

(Figs. 46, 70, 130, 131, 150, 217)

Euschöngastia cricticola Brennan, 1949, Jour. Parasit., vol. 34, p. 473 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1340 (*larva*).

Description of nymph.—Body: About 0.7 mm. long, color yellow to orange. Body setae branched as usual; tips of posterior setae ending in 2 to 4 short attenuated branches; posterior setae about 60 μ long. Sternum roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 8 specimens); TL: 118.1 ± 1.86 , TH: 51.0 ± 1.53 , TL/TH: 2.34 ± 0.0962 .

Gnathosoma: Basis capituli of usual shape. Cheliceral base somewhat stout, puncta few; blade stout, shearlike, with about 13 teeth of varying sizes. Cheliceral measurements (means of 10 specimens); BL: 100.7 ± 1.764 , BH: 37.5 ± 1.241 , CL: 46.8 ± 0.554 , BL/BH: 2.73 ± 0.120 , BL/CL: 2.14 ± 0.043 . Palpus normal, rather small; tarsala about 11 μ long; tarsus with 3 inner, 1 outer

apical nude setae. Setal counts; femur (6 specimens): 3.67 ± 0.3587 , genu (7 specimens): 7.43 ± 0.5279 , tibia: range 4-5, tarsus: range 8-9.

Scutum: Tectum moderate in size. Sensillary area with basal plate of two narrow bands; apodeme much reduced; bulla triangular; carina thin; ridges weak; anterior margin often with one or two small toothlike projections directly anterior to sensillary bases; sensilla slightly thickened but flexible, with short branches along entire length. Scutal measurements (means of 7 specimens); ASL: 81.6 ± 2.861 , SB: 36.8 ± 1.031 , TS: 27.0 ± 1.448 , SENS: about 100, ASL/SB: 2.14 ± 0.0645 .

Remarks.—*Euschöngastia criceticola* appears to be a widespread chigger in western North America (see Loomis, 1956:1341). There may be more than one form of larva considered under this name. The nymphs described here are associated with the larval form treated by Loomis (1956:1340).

This species was reared on three occasions. There are no records of feeding by the nymphs, but since some adults were obtained the nymphs evidently fed. The food was probably collembola eggs which were added to the cultures as food material.

Specimens examined.—Total 41 nymphs, as follows: KANSAS. *Barber County*: $3\frac{1}{2}$ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (39 nymphs, reared LJL); 4 mi. S Aetna, *Neotoma micropus*, October 6, 1951 (1 nymph, reared LJL). *Russell County*: 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus*, April 27, 1952 (1 nymph, reared DAC).

Euschöngastia cynomyicola Crossley and Lipovsky

(Figs. 50, 67, 212)

Euschöngastia cynomyicola Crossley and Lipovsky, 1954, Proc. Ent. Soc., Washington, vol. 46, pp. 240-243 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1342 (*larva*).

Description of nymph.—Resembles *E. criceticola* except as follows:

Body: About 0.4 mm. long, color not known. Tips of posterior body setae blunt, ending in one or two minute, but thick, branches; posterior setae about 35μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 10 specimens); TL: 113.0 ± 5.34 , TH: 53.3 ± 1.044 , TL/TH: 2.11 ± 0.0722 .

Gnathosoma: Cheliceral base stout; blade normal, shearlike, with about 18 small to tiny teeth. Cheliceral measurements (means of 10 specimens); BL: 101.6 ± 2.945 , BH: 41.5 ± 0.969 , CL: 48.9

± 1.197 , BL/BH: 2.46 ± 0.0748 , BL/CL: 2.08 ± 0.029 . Palpus rather stout, tarsala about 9μ long. Setal counts (means of 11 specimens); femur: 8.45 ± 0.3763 , genu: 9.85 ± 0.6012 .

Scutum: Measurements (means of 10 specimens); ASL: 86.8 ± 3.339 , SB: 42.4 ± 0.897 , TS: 29.6 ± 0.653 , SENS: about 110, ASL/SB: 2.05 ± 0.0521 .

Remarks.—This species is very similar to, although somewhat smaller than, *Euschöngastia criceticola*. As larvae the two are readily separable on several characters. *Euschöngastia cynomyicola* was cultured once. No records of feeding are available, and no adults were obtained from the culture. Evidently the nymphs either refused the collembolans and their eggs, or these were inadequate food materials.

Specimens examined.—Total 12 nymphs, as follows: NEBRASKA. *Hitchcock County*: 4 mi. E Stratton, *Cynomys ludovicianus*, August 8, 1949 (12 nymphs, reared LJL).

Euschöngastia diversa Loomis

(Figs. 49, 215)

Euschöngastia diversa Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1337 (larva).

Description of nymph.—Body: About 0.6 mm. long, color orange to yellow. Body setae resembling those of *E. criceticola* but posterior setae ending in 2 to 4 short branches, these sometimes compound; posterior setae about 50μ long. Sternum roughly pentagonal, with about 10 setae. Measurements of tarsus I (means of 6 specimens); TL: 124.0 ± 3.85 , TH: 66.3 ± 1.41 , TL/TH: 1.87 ± 0.0212 .

Gnathosoma: Cheliceral base stout, puncta numerous; blade stout, shortened, shearlike, with about 13 large to small teeth. Cheliceral measurements (means of 6 specimens); BL: 102.0 ± 3.507 , BH: 43.3 ± 1.282 , CL: 52.3 ± 1.308 , BL/BH: 2.38 ± 0.1046 , BL/CL: 2.00 ± 0.0516 . Palpus somewhat stout, accessory claws somewhat shortened; tarsala about 10μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts; femur (3 specimens); 5.0 ± 0.000 , genu (4 specimens): 8.75 ± 0.595 , tibia: range 4-6, tarsus: range 9-10.

Scutum. Tectum moderate in size, seta elongate. Sensillary area with basal plate of two widely separated bandlike halves; apodeme much reduced or absent; bulla small, triangular; carina prominent, often doubled posteriorly; strong ridges anterior to and posterior to sensillary bases, other ridges weak; anterior margin of sensillary

area with three or four broad, prominent, toothlike projections covering most of margin; sensillum like that of *E. criceticola*. Scutal measurements (means of 6 specimens); ASL: 95.8 ± 4.489 , SB: 36.3 ± 1.606 , TS: 30.0 ± 0.894 , SENS: about 125, ASL/SB: 2.65 ± 0.1335 .

Remarks.—As both larva and postlarva, *E. diversa* is very similar to *E. peromysci*. Nymphs of these two species are separable by the nature of the tips of the posterior body setae, as indicated in the key to species. This character varies in both species. Many specimens of *E. diversa* have the tips of these setae divided into several short attenuate branches, but others have these branches compoundly branched. When a lateral branch arises very near the tip, the setae resemble those of *E. peromysci*. In none of the material examined was there any difficulty in separating these two species by this character, however.

This species was reared on several occasions. The nymphs utilized collembolan eggs as food, and several adults were obtained.

Specimens examined.—Total 87 nymphs, as follows KANSAS. *Douglas County*: Lawrence, *Neotoma floridana*, December 9, 1949 (26 nymphs, reared LJL); 3 mi. W Lawrence, *Neotoma floridana*, March 2, 1949 (1 nymph, reared LJL) and March 5, 1949 (53 nymphs, reared LJL); 4 mi. N, 1 mi. E Lawrence, *Neotoma floridana*, December 9, 1948 (1 nymph, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Neotoma floridana*, March 4, 1949 (2 nymphs, reared LJL). *Johnson County*: 2 mi. W, 1 mi. N Lenexa, *Sylvilagus floridanus*, November 18, 1953 (3 nymphs, reared RBL). *Miami County*: 2 mi. W, 1 mi. S Louisburg, *Sylvilagus floridanus*, November 24, 1953 (1 nymph, reared RBL, idet. by larval skin).

Euschöngastia jonesi Lipovsky and Loomis

(Figs. 26, 64, 108, 109, 153, 216)

Euschöngastia jonesi Lipovsky and Loomis, 1954, Jour. Parasit., vol. 40, pp. 407-410 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1332-1333 (*larva*).

Description of nymph.—Body: About 0.7 mm. long, color yellow to white. Body setae like those of *E. criceticola*, but posterior setae ending in tips of 2 to 4 short branches, which are surpassed by a long semiterminal lateral branch; posterior setae about 90 μ long. Sternum elongated-rectangular, with about 8 setae. Measurements of tarsus I (means of 7 specimens); TL: 147.0 ± 4.999 , TH: 71.3 ± 1.340 , TL/TH: 2.06 ± 0.0429 .

Gnathosoma: Basis capituli rather short, broad. Cheliceral base somewhat stout, puncta numerous; blade shearlike but thinner, and

elongated, with about 20 small to tiny teeth. Cheliceral measurements (means of 7 specimens); BL: 127.3 ± 4.279 , BH: 50.0 ± 1.309 , CL: 68.0 ± 1.448 , BL/BH: 2.56 ± 0.2243 , BL/CL: 1.87 ± 0.3394 . Palpus normal, rather large; tarsala about 15μ long; tarsus with 4 or 5 apical nude setae. Setal counts (means of 7 specimens); femur: 4.5 ± 0.2886 , genu: 11.64 ± 0.8360 , tibia: range 4-6, tarsus: range 8-10.

Scutum: Tectum moderate in size; seta elongated. Sensillary area with basal plate normal, apodeme much reduced; bulla triangular; carina prominent; strong ridges anterior and posterior to sensillary bases; sensilla slightly thickened but flexible; short basal branches numerous but branches on distal portion few, and short. Scutal measurements (means of 7 specimens); ASL: 128.5 ± 2.79 , SB: 43.6 ± 0.922 , TS: 47.0 ± 1.964 , SENS: about 150, ASL/SB: 2.67 ± 0.0334 .

Remarks.—*Euschöngastia jonesi* is similar to *E. pipistrelli* particularly in details of the scutum. The two species are separable by characters of the gnathosoma but most readily by the nature of the tips of the posterior body setae: *E. jonesi* has setae ending in several short branches, while *E. pipistrelli* has setae ending in a single long branch. The two species are also similar as larvae.

The nymphs were readily maintained in culture. They fed upon collembola eggs.

Specimens examined.—Total 7 nymphs, as follows: KANSAS. *Barber County*: 4 mi. S Aetna, *Peromyscus maniculatus*, October 7, 1951 (1 nymph, reared DAC). *Cowley County*: 2 mi. E Rock, *Peromyscus leucopus*, March 7, 1953 (6 nymphs, reared DAC, idet. by larval skins; reared from larvae associated with the type series).

Euschöngastia peromysci (Ewing)

(Figs. 48, 66, 104, 105, 152, 214)

Schöngastia peromysci Ewing, 1929, Ent. News, vol. 40, p. 296 (*larva*).

Euschöngastia peromysci Fuller, 1948, Bull. Brooklyn Ent. Soc., vol. 43, p. 108 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1334-1335 (*larva*).

Description of nymph.—Resembles *E. diversa* except as follows:

Body: Posterior body setae ending in slightly expanded tips, which give rise to several short compound branches, each seta with a thickened subterminal lateral branch surpassing the tip; posterior setae about 35μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 9 specimens); TL: 133.1 ± 0.558 , TH: 73.1 ± 0.7536 , TL/TH: 1.83 ± 0.0167 .

Gnathosoma: Cheliceral blade with about 18 rather small to tiny teeth. Cheliceral measurements (means of 9 specimens); BL: 115.4 ± 4.176 , BH: 48.0 ± 0.957 , CL: 60.3 ± 0.965 , BL/BH: 2.41 ± 0.0588 , BL/CL: 1.88 ± 0.325 . Palpus with tarsala about 12μ long. Setal counts (means of 9 specimens); femur: 3.83 ± 0.2041 , genu: 10.0 ± 0.4961 , tibia: range 4-5.

Scutum: Measurements (means of 10 specimens); ASL: 105.9 ± 1.645 , SB: 43.4 ± 0.499 , TS: 38.6 ± 1.335 , SENS: about 145, ASL/SB: 2.44 ± 0.0445 .

Remarks.—This species shows the most extreme modification of the tips of the posterior body setae. The minute compound branches of the tip are often distributed along the prominent lateral branch, for about half of its length. The characteristics of these setae are adequate for recognition of the species. A specimen from Shelby County, Tennessee, shows a deviate condition: Two instead of one prominent subterminal branches, forming about a ninety-degree angle. Larvae from which this nymph was reared are typical *peromysci*. Since *E. peromysci* is primarily an eastern species, this two-spined tip may be more characteristic.

In culture, nymphs of *E. peromysci* ate collembolan eggs.

Specimens examined.—Total 19 nymphs, as follows: KANSAS. *Cowley County*: 2 mi. E Rock, *Peromyscus leucopus*, March 7, 1953 (7 nymphs, reared DAC, idet. by larval skins). *Douglas County*: Lawrence, *Sylvilagus floridanus*, Lawrence, November 12, 1949 (1 nymph, reared LJL), and *Neotoma floridana*, March 30, 1949 (2 nymphs, reared LJL); 5 mi. N, 1 mi. E Lawrence, *Neotoma floridana*, February 18, 1950 (1 nymph, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Neotoma floridana*, March 4 and 5, 1949 (3 nymphs, reared LJL). *Jefferson County*: $5\frac{1}{2}$ mi. N Lawrence, *Peromyscus leucopus*, January 25, 1952 (2 nymphs, reared DAC). *Johnson County*: Roeland Park, *Sylvilagus floridanus*, November 10, 1953 (2 nymphs, reared RBL). TENNESSEE. *Shelby County*: *Peromyscus leucopus*, January 31, 1954 (1 nymph, reared DAC, idet. by larval skin).

Euschöngastia pipistrelli Brennan

(Figs. 28, 225)

Euschöngastia pipistrelli Brennan, 1947, Jour. Parasit., vol. 33, p. 249 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1331-1332 (*larva*).

Description of nymph.—Resembles *E. jonesi*, except as follows:

Body: About 1.0 mm. long, color not known. Body setae like those of *E. criceticola*, with branches rather long; tips single, long, attenuated; posterior setae about 105μ long; posterior setae mark-

edly longer than dorsal subposterior setae. Sternum roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 4 specimens); TL: 196.0 ± 5.788 , TH: 81.3 ± 1.109 , TL/TH: 2.40 ± 0.410 .

Gnathosoma: Cheliceral base apparently without puncta; blade of usual shearlike shape, with about 25 small to tiny teeth. Cheliceral measurements (means of 4 specimens); BL: 129.5 ± 3.97 , BH: 55.0 ± 2.35 , CL: 67.5 ± 2.33 , BL/BH: 2.38 ± 0.233 , BL/CL: 1.93 ± 0.008 . Palpus with tarsala about 13 μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 4 specimens); femur: 7.88 ± 1.0784 , genu: 15.75 ± 1.4790 , tibia: range 4-7, tarsus: range 10-13.

Scutum: Sensillum resembling that of *E. criceticola*. Scutal measurements (means of 3 specimens); ASL: 141.3 ± 2.03 , SB: 54.8 ± 0.629 , TS: 41.0 ± 2.000 , ASL/SB: 2.60 ± 0.0577 .

Remarks.—*Euschöngastia pipistrelli* is restricted in the larval stage to bats, while its closest relative, *E. jonesi*, occurs on other mammals as well. It seems logical to expect that the nymphal stage of a bat parasite, particularly a cave bat, would possess morphological features indicating adaptation to a cave habitat. However, *E. pipistrelli* resembles other species of *Euschöngastia* more closely than does *E. jonesi*, which can evidently persist in caves or in other habitats.

The larval forms of both species appear similar to the type of the genus, *E. sciuricola*; Loomis placed them in the subgenus *Euschöngastia*.

Specimens examined.—Total 4 nymphs, as follows: OKLAHOMA. *Adair County*: 5 mi. S. Kansas border ($9\frac{1}{2}$ S Aetna, Kansas), *Pipistrellus subflavus*, March 5, 1950 (4 nymphs, reared LJL).

Euschöngastia setosa (Ewing)

(Figs. 27, 29, 65, 102, 103, 156, 213)

Trombicula setosa Ewing, 1937, Proc. Biol. Soc. Washington, vol. 50, pp. 170-171 (*larva*).

Euschöngastia setosa, Fuller, 1948, Bull. Brooklyn Ent. Soc., vol. 43, p. 103 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1329 (*larva*).

Description of nymph.—Body: Large, about 1.0 mm. long, color pale orange. Body setae like those of *E. diversa*; short branches at tip never with compound branching; posterior setae about 55 μ long. Sternum roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 5 specimens); TL: 174.0 ± 5.162 , TH: 72.8 ± 2.834 , TL/TH: 2.04 ± 0.0610 .

Gnathosoma: Cheliceral base of usual shape, punctate; blade shearlike, with about 22 small teeth. Cheliceral measurements (means of 9 specimens); BL: 136.1 ± 3.116 , BH: 53.2 ± 1.128 , CL: 73.6 ± 1.987 , BL/BH: 2.57 ± 0.0527 , BL CL: 1.86 ± 0.0176 . Palpus large and stout; tarsala about 14μ long; tarsus with 4 or 5 apical nude setae. Setal counts; femur (6 specimens): 18.5 ± 0.4831 , genu (8 specimens): 9.94 ± 0.6371 , tibia: range 5-8, tarsus: range 9-11.

Scutum: Tectum large, seta long. Sensillary area with basal plate of rather characteristic shape; apodeme reduced; bulla triangular; carina thin but prominent; strong ridges anterior and posterior to sensillary bases; other ridges weak; anterior margin of sensillary area with 2 (occasionally 1) elongated, rather characteristic toothlike projections directly in front of sensillary bases; sensillum like that of *E. criceticola*. Scutal measurements (means of 8 specimens); ASL: 123.0 ± 4.957 , SB: 46.2 ± 1.172 , TS: 49.5 ± 2.044 , SENS: about 135, ASL/SB: 2.69 ± 0.0639 .

Remarks.—Of the species considered here, *E. setosa* seems to be the most closely related to the type of the genus, *E. sciuricola*, judging from their larvae. Nymphs of *sciuricola* are unknown.

Several characters which separate *E. setosa* from other *Euschön-gastia* species involve size; *E. setosa* is the largest of these nymphs. Otherwise some scutal details appear distinctive, as noted above.

In culture, nymphs of *E. setosa* ate Collembola eggs. Several adults were obtained from the cultures.

Specimens examined.—Total 22 nymphs, as follows: ARKANSAS. Polk County: 2 mi. NE Mena, *Cryptotis parva*, March 3, 1951 (1 nymph, reared LJL). KANSAS. Barber County: 4 mi. S Aetna, *Neotoma micropus*, October 6, 1951 (1 nymph, reared DAC), and *Peromyscus leucopus*, October 7, 1951 (1 nymph, reared DAC); $3\frac{1}{2}$ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (4 nymphs, reared LJL); 5 mi. S Sun City, *Neotoma micropus*, April 12, 1949 (1 nymph, reared LJL). Cowley County: 2 mi. E Rock, *Peromyscus leucopus*, March 7, 1953 (1 nymph, reared DAC, idet. by larval skin). Douglas County: 1 mi. N, 5 mi. E Lawrence, *Neotoma floridana*, November 23, 1951 (1 nymph, reared DAC). Johnson County: Roeland Park, *Sylvilagus floridanus*, November 10, 1953 (9 nymphs, reared RBL); 2 mi. N, 1 mi. W Lenexa, *Sylvilagus floridanus*, November 18, 1954 (2 nymphs, reared RBL). Russell County: 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus*, April 27, 1952 (1 nymph, reared DAC).

Euschöngastia trigenuala Loomis

(Figs. 45, 68, 120, 121, 151, 192, 220)

Euschöngastia trigenuala Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1343 (larva).

Description of nymph.—Body: About 0.8 mm. long, color white. Setae somewhat expanded, with fine branches; tips rounded, with 2 or 3 shorter branches; posterior setae markedly longer than dorsal subposterior setae; posterior setae about 85 μ long. Sternum roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 8 specimens); TL: 119.3 ± 2.058 , TH: 56.4 ± 1.252 , TL/TH: 2.14 ± 0.0497 .

Gnathosoma: Cheliceral base stout, puncta numerous; blade stout, shearlike, apodeme of blade markedly constricted; with about 13 rather large, flat teeth. Cheliceral measurements (means of 10 specimens); BL: 98.0 ± 1.361 , BH: 41.2 ± 0.743 , CL: 53.8 ± 1.104 , BL/BH: 2.38 ± 0.0133 , BL/CL: 1.81 ± 0.0233 . Palpus stout, claw somewhat thin; tarsala about 14 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 4.45 ± 0.1740 , genu: 8.65 ± 0.3078 , tibia: range 4-6, tarsus: range 9-10.

Scutum: Tectum moderate in size. Sensillary area with basal plate of two bands as usual; apodeme much reduced; bulla triangular; carina thin; rather strong ridges anterior to and posterior to sensillary bases; other ridges weak; anterior margin sometimes with inconspicuous toothlike projections directly in front of sensillary bases; sensilla slightly thickened but flexible, with branches numerous on basal half but distal one third to one fourth entirely nude, attenuated. Scutal measurements (means of 10 specimens); ASL: 81.8 ± 1.597 , SB: 37.2 ± 0.646 , TS: 27.8 ± 1.236 , SENS: about 116, ASL/SB: 2.21 ± 0.0407 .

Remarks.—The closest relatives of *E. trigenuala* are not obvious. As both larva and nymph, the species has several distinctive features but these are not so striking as to suggest that *E. trigenuala* is far removed from the other species. Nymphs of *trigenuala* are easily recognized by the nude, tapered tip of the sensillum. Loomis (1956-1344) shows that larvae of *E. trigenuala* seem to prefer fossorial mammals, suggesting that the postlarvae may live in the subterranean burrows. No nymphs were reared from truly fossorial hosts.

Specimens examined.—Total 17 nymphs, as follows: KANSAS, Douglas County: 1 mi. E, 5 m. N Lawrence, *Microtus ochrogaster*,

February 20, 1952 (4 nymphs, reared DAC). *Johnson County*: 2 mi. N, 1 mi. W Lenexa, *Microtus ochrogaster*, April 2, 1954 (1 nymph, reared DAC). *Lyon County*: 2 mi. S Chalk, *Perognathus hispidus*, May 31, 1950 (10 nymphs, reared LJL). *Russell County*: 9 mi. S Russell, *Peromyscus maniculatus*, April 26, 1952 (1 nymph, reared DAC). TENNESSEE. *Shelby County*: 6 mi. N Memphis, *Microtus pinetorum*, February 2, 1954 (1 nymph, reared DAC, idet. by larval skin).

Genus *Euschöngastoides* Loomis, New Status

Trombicula (*Euschöngastoides*) Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, p. 924 (type *Trombicula* (*Euschöngastoides*) *hoplai* Loomis) (larva).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, not expanded, tips variable; without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorso-apical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome short, blunt, with about twenty short apical nude or nearly nude setae.* (9) *Pharynx marked with a reticulate pattern.* (10) Tectum broad, hyaline, *with small serrations on margin*, and with one small tectal seta. (11) *Sensillary area wide*; mean ratio ASL/SB: 1.2-1.3. (12) Without branched body seta in sensillary area. (13) Sensilla almost flagelliform but slightly thickened, with branches.

Additional features (nymph).—(14) Body size medium (about 0.6 mm. long), of usual shape. (15) Sternum roughly rectangular, closed behind. (16) Tarsus I but slightly elongated. (17) *Articulating area of cheliceral base with basis capituli posterior; base with posterior tip elevated.* (18) Palpus stout, small; distal portion of tibia not unusually elongated; claw slightly curved, moderate in size; two accessory claws; tarsus with five to seven branched setae and *two apical nude setae.* (19) Hypostome with about ten ventral branched setae. (20) Basis capituli short, broad. (21) Crista short, narrow. (22) Sensillary area with basal plate of two well-separated halves; bulla triangular, moderate in size; carina absent; sensillary bases placed well lateral; ridges weak, apodeme apparently absent. (23) About ten parascutal setae.

Remarks.—*Euschöngastoides* was erected by Loomis as a subgenus of *Trombicula* for *T. hoplai* Loomis. At that time Loomis noted that the affinities of *T. hoplai* appeared to be with certain species of *Euschöngastia* rather than with other species of *Trom-*

bicula, despite the fact that the sensilla of *T. hoplai* (as larva) are not expanded. The species of *Euschöngastia* which are particularly similar are *E. finleyi* Crossley, *E. lacerta* Brennan, and *E. loomisi* Crossley and Lipovsky. Nymphs of *E. loomisi* were obtained. It became evident that *E. loomisi* and *T. hoplai* were very similar in the nymphal as well as in the larval stage, and that the nymphs were abundantly distinct from those of other species of *Trombicula* and *Euschöngastia*.

This is certainly not the first instance of similar larval forms being separated in the two genera *Trombicula* and *Euschöngastia* on the basis of difference in sensilla (see Audy, 1954:133 concerning confusion of larvae of *T. munda* and *E. indica*). In the present case, however, the nymphs have been reared, and have been found to show strong similarities to each other and appear to have affinities with different genera from those in which the larvae were placed.

These two species present a taxonomic dilemma. To leave them in the genera where they were originally placed would be in effect to ignore evidence of the postlarval stages, not only by separating two very similar nymphs but by placing them with groups which are markedly different. To place the species on postlarval evidence alone (perhaps in *Pseudoschöngastia*, nymphs of which are quite similar) would be to ignore evidence from the larval stage, in particular the nature of the sensilla, which separates the two major genera *Trombicula* and *Euschöngastia*. After careful consideration it appears that the flaw must lie in the rigid application of the single larval character, flagelliform sensilla versus expanded sensilla. Even in the larval stage the two species are similar except in the sensilla. The solution which does the least violence to both systems of classification appears to be the recognition of full generic status for *Euschöngastoides* and the inclusion of *E. loomisi* in that genus.

The genus *Euschöngastoides* will be very difficult to recognize in the larval stage until more species have been reared and a much better understanding of its limits obtained. It is proposed that for the time being no species be placed in this genus on the evidence of either larval or postlarval stages alone.

The relationships of the genus *Euschöngastoides* appear to be with *Pseudoschöngastia* and *Walchia*. Together, these three genera are separable from other trombiculine genera by the following diagnostic characters: (8) Hypostome short, blunt, with about twenty short apical nude or nearly nude setae. Other genera have

the hypostome longer, usually pointed, with about eight apical nude setae. (9) Pharynx marked with a reticulate pattern. In other genera the pharynx is unmarked. (11) Mean ratio ASL/SB: 1.2-1.7. In other genera the mean ratio ASL/SB is 2.0 or greater (except *Guntherana* and *Doloisia*, as described by other authors). (17) Articulating area of cheliceral base with basis capituli posterior, base with posterior tip elevated. In other genera the articulating area is on the ventral surface rather than across the posterior end. The posterior tip of the cheliceral base is depressed. There are several additional characters which indicate relationship between these three genera. As previously discussed, these genera may form a valid subfamily, but since larvae of *Euschöngastoides* are at present not separable from those of *Trombicula* and *Euschöngastia*, recognition of such a subfamily seems impractical.

The genus *Schoutedenichia*, which I have not studied, appears related to the *Euschöngastoides* group of genera. Descriptions and illustrations of nymphs of *Schoutedenichia* indicate that they share the features listed above.

Euschöngastoides is separable from *Pseudoschöngastia* by the nature of the sensilla (rather thin and quite flexible in *Euschöngastoides*, thicker and but slightly flexible in *Pseudoschöngastia*) and by the tectal margin (smooth in *Pseudoschöngastia*, with small teeth in *Euschöngastoides*). *Walchia* differs from *Euschöngastoides* in several characters, including the absence of a tectal seta and the possession of a dorsoapical stumplike process on tarsus I in *Walchia*.

Nymphs of *Euschöngastia perameles* (Womersley) and *E. smithi* (Womersley) have been described by Domrow (1955). The descriptions and illustrations indicate that these nymphs will probably key out to *Euschöngastoides*. Possibly, they would fall in *Pseudoschöngastia*. At any rate, it is evident that these species belong in the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera and not in *Euschöngastia*. These species share with the *Euschöngastoides* group of genera the pertinent characteristics (8), (11), and (17); two species possess precoxal plates and so violate character (2) for *Euschöngastoides* and its relatives. Larvae of *E. perameles* and *E. smithi* have been described by Womersley; scuta of these larvae are similar to those of species of *Euschöngastoides*. I am uncertain as to whether these two species should be accommodated in *Euschöngastoides*, *Pseudoschöngastia*, or a new genus.

The nymph of *Euschöngastia indica* (Hirst) as described by Wharton (1946:159-161) suggests that this species may belong to

Euschöngastoides. Wharton's description is not sufficiently complete to make placement positive.

KEY TO SPECIES OF EUSCHÖNGASTOIDES (NYMPHS)

1. Posterior body setae with tips ending in 2-4 attenuated branches; tectal seta longer (about 12 μ) with more branches *hoplai* p. 229
2. Posterior body setae with tips rather abruptly pointed and bearing 6 or more very minute branches; tectal seta shorter (about 7 μ) with fewer branches *loomisi* p. 230

Euschöngastoides hoplai (Loomis) New Combination

(Figs. 31, 87, 126, 127, 146, 179, 186, 219)

Trombicula (*Euschöngastoides*) *hoplai* Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 294-296 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1305-1306 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color white. Setae rather short, with fine branches tending to project at right angles from stems; tips of posterior setae ending in 2 to 4 short attenuated branches; posterior setae about 35 μ long. Sternum roughly rectangular in shape, rather distinctive, with 4 to 6 setae. Measurements of tarsus I (means of 10 specimens); TL: 86.2 ± 3.095 , TH: 50.9 ± 0.924 , TL/TH: 1.69 ± 0.0526 .

Gnathosoma: Pharynx with reticulate markings covering about half its width. Cheliceral base stout, distinctive in shape, punctate; blade elongated but shearlike, apodeme of blade not constricted and rather narrow; blade with about 9 rather small teeth commonly on distal half. Cheliceral measurements (means of 12 specimens); BL: 52.3 ± 1.534 , BH: 25.6 ± 0.4345 , CL: 24.8 ± 0.7054 , BL/BH: 2.03 ± 0.0467 , BL/CL: 2.10 ± 0.0264 . Palpus stout, small; accessory claws thin; dorsal tibial setae large; tarsala about 6 μ long; tarsus with 1 inner and 1 outer apical nude setae. Setal counts (means of 7 specimens); femur: 6.93 ± 0.3996 , genu: 8.00 ± 0.2182 , tibia: 5 (no variation), tarsus: range 6-7.

Scutum: Tectum with about 15-20 small serrations on margin; seta short but small branches rather numerous. Crista very narrow. Sensillary area with ridges weak but visible; no ridges medial to sensillary bases; sensilla flexible; longer branches on distal part of sensilla tend to run at right angles to stems, stems assume zigzag appearances near apex. Scutal measurements (means of 10 specimens): ASL: 52.2 ± 1.769 , SB: 42.2 ± 1.872 , TS: 12.2 ± 1.278 , SENS: about 75, ASL/SB: 1.26 ± 0.0372 .

Remarks.—This species is apparently widely distributed in the

central and southwestern United States. Postlarvae probably inhabit the soil surrounding the nests of their mammalian hosts.

Euschöngastoides hoplai proved very difficult to culture. The inactive stages seem unusually susceptible to mold. The nymphs move very sluggishly. Both Collembola eggs and crushed collembolans were offered as food materials, but the nymphs did not eat.

An obvious question concerns the proper identification of the nymphal stages of *E. loomisi* and *E. hoplai*. A field trip was made to Barber County, Kansas, in 1955, with specific objective of obtaining unquestionable evidence of the nymphal identification. In the case of *E. loomisi* this was achieved, by the isolated rearing of a single individual and recovery of the larval skin. Several individuals of *E. hoplai* were found but none reached the nymphal stage. There is, however, strong evidence associating the nymphal form with the larvae of *E. hoplai*. This species was reared by me on two occasions; in both instances larvae similar to those placed in culture were identified as *E. hoplai* when the culture was started. Dead larvae removed from the cultures were *E. hoplai*. No nymphs of this type were reared in mixed cultures, nor were any found as contaminants of other cultures. Also, the association of larva and nymph was observed independently (and preceding my work) by Louis J. Lipovsky. Thus it appears most certain that the nymphs described as *E. hoplai* are correctly identified.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. Barber County: 1 mi. W, 4½ mi. S Aetna, *Cynomys ludovicianus*, July 27, 1952 (7 nymphs, reared DAC); 10½ mi. W Hardtner, *Cynomys ludovicianus*, July 26, 1952 (1 nymph, reared DAC); 4 mi. S Aetna, *Neotoma micropus*, August 22, 1949 (4 nymphs, reared LJJL).

Euschöngastoides loomisi (Crossley and Lipovsky),

New Combination

(Figs. 8, 30, 223)

Euschöngastia loomisi Crossley and Lipovsky, 1954, Proc. Ent. Soc. Washington, vol. 56, pp. 243-246 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1346-1347 (*larva*).

Description of nymph.—Resembles *E. hoplai* except as follows:

Body: About 0.6 mm. long. Setae with tips rather abruptly pointed, with variable number (six or more) very tiny branches; posterior setae about 40 μ long. Measurements of tarsus I (means of 9 specimens); TL: 78.9 ± 1.006 , TH: 46.4 ± 0.989 , TL/TH: 1.70 ± 0.0236 .

Gnathosoma: Cheliceral base with few puncta; blade with apodeme shorter and broader; with about 9 teeth restricted to distal

half of blade. Cheliceral measurements (means of 10 specimens); BL: 51.5 ± 0.6709 , BH: 24.2 ± 0.5541 , CL: 24.2 ± 0.4899 , BL/BH: 2.14 ± 0.0494 , BL/CL: 2.14 ± 0.0394 . Palpus with tarsala about 5μ long. Setal counts; femur (8 specimens): 5.63 ± 0.2060 , genu (10 specimens): 7.3 ± 0.3267 , tibia: range 4-6, tarsus: range 5-6.

Scutum: Tectal seta smaller, with fewer branches. Scutal measurements (means of 8 specimens); ASL: 51.0 ± 1.662 , SB: 46.1 ± 1.576 , TS: 7.25 ± 0.4532 , SENS: about 90, ASL/SB: 1.17 ± 0.0361 .

Remarks.—Like *E. hoplai*, *E. loomisi* nymphs were inactive in culture. They were not observed to feed on the Collembola eggs and crushed collembolans offered to them.

Euschöngastoides loomisi is known from the central and southwestern United States and from northern Mexico. Postlarvae probably inhabit the soil surrounding the nests and burrows of their mammalian hosts.

Specimens examined.—Total 17 nymphs, as follows: KANSAS. Barber County: 4 mi. S Aetna, *Neotoma micropus*, July 11, 1955 (1 nymph, reared RBL, idet. by larval skin) and August 22, 1949 (13 nymphs, reared LJL), and *Peromyscus maniculatus*, October 7, 1951 (1 nymph, reared LJL); 3 mi. E, 5 mi. S Aetna, *Neotoma micropus*, July 25, 1952 (1 nymph, reared DAC); $10\frac{1}{2}$ mi. W Hardtner, *Cynomys ludovicianus*, July 26, 1952 (1 nymph, reared DAC).

Genus *Neoschöngastia* Ewing

Neoschöngastia Ewing, 1929, Manual of External Parasites, Springfield, Ill., Thomas, p. 187 (type *Schöngastia americana* Hirst) (*larva*); Wharton and Hardcastle, 1946, Jour. Parasit., vol. 32, p. 288 (*nymph*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 84 (*nymph*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 388 (*nymph*).

Diagnosis (nymph).—(1) Eyes absent. (2) *Precoxal plates of coxae I present but not fused in midline to form longitudinally divided sternum.* (3) *Body setae with compound branching; not expanded; long and short setae intermixed.* (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade narrowed but shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome projecting but blunt at tip; with about eight short apical nude setae.* (9) Pharynx indistinct. (10) Tectum large, hyaline, with teeth; with one tectal seta. (11) *Sensillary area reniform; mean ratio ASL/SB: about 2.0-2.2.* (12) Without branched body seta in sensillary area. (13) Sensilla variable, with branches.

Additional features (nymph).—(14) Body size medium (about 0.6 mm. long), strongly constricted, truncate posteriorly. (15) Precoxal plates of coxae I touching in midline but not fused; sternum open posterior to plates. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral but shortened; base with posterior tip depressed. (18) Palpus unusually stout, broad; usually elongated; claw curved, *extremely elongated in American species; one or two accessory claws*; tarsus with about nine nude or nearly nude setae and one apical nude seta. (19) Hypostome with ten to twenty ventral branched setae. (20) Basis capituli of usual shape. (21) Crista long but not narrowed, rod-like. (22) Sensillary area with basal plate of two rather widely separated halves; bulla much reduced in size; carina absent; sensillary bases rather small, *placed well forward*; ridges present but variable; apodeme much reduced. (23) About ten parascutal setae.

Remarks.—In addition to the nymphs described in the present paper, others have been described. Wharton and Hardcastle (1946: 288) published descriptions of the nymphs of *N. carveri* Wharton and Hardcastle and another species, either *americana solomonis* Wharton and Hardcastle or *monticola* Wharton and Hardcastle. The nymph of *N. gallinarum* (Hatori) has been described by Womersley (1952:390-391). The foregoing diagnosis is in agreement with these published accounts, except as follows: The palpal claws of other than American species are not extremely elongated. No mention is made of the presence or absence of precoxal plates, either by Wharton and Hardcastle or by Womersley. The single nymph of *N. carveri* has two tectal setae and is probably aberrant in this respect.

As larvae, species of *Neoschöngastia* are recognized by the submergence of the scutum beneath the cuticular striae. The larvae otherwise appear similar to many species now placed in *Euschöngastia*.

Although the larvae are placed by this single key character, nymphs are abundantly distinct from those of other genera. It is difficult to suggest to which genera *Neoschöngastia* may be related. The nymphal scutum is distinctive; it is somewhat suggestive of *Cheladonta* but nymphs of these two genera seem specialized along different lines and certainly do not share many other features. Of the characters listed above, the elongated palpal claws are the most ready means of identification for the American forms. Otherwise,

the body setae are distinctive in being compoundly branched long and short setae being intermixed.

Womersley (1952:389) gives an adequate key to the known nymphs of *Neoschöngastia*. American species are easily separated from these by their very elongated palpal claws. The two American species are themselves separated in the following key.

KEY TO AMERICAN SPECIES OF NEOSCHÖNGASTIA (NYMPHS)

1. Cheliceral blade without teeth; palpal tibia with two accessory claws; sensilla not expanded in midregions, flexible, with long branches restricted to distal third *brennani* p. 234
2. Cheliceral blade with teeth; palpal tibia with one accessory claw; sensilla somewhat expanded in midregion, with numerous spinelike branches not restricted to distal third *americana* p. 233

Neoschöngastia americana (Hirst)

(Figs. 40, 71, 177, 180, 193, 194, 201, 222, 224)

Schöngastia americana Hirst, 1921, Ann. and Mag. Nat. Hist., vol. 17, p. 37 (*larva*).

Neoschöngastia americana, Ewing, 1929, Manual of External Parasites, Springfield, Ill., Thomas, p. 187 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1354-1355 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color red. Setae with thick stems and short thick branches which in turn divide into 2-4 fine branches; tips of posterior setae with 2-3 shorter compound branches; longer body setae about four times as long as shorter ones; long posterior setae about 70 μ long. Sternum with rounded precoxal plates of coxae I meeting at midline, each plate bearing 2-4 setae; sternal area open behind. Legs appear shortened. Measurements of tarsus I (means of 10 specimens); TL: 95.4 ± 0.9214 , TH: 49.0 ± 0.5164 , TL/TH: 1.94 ± 0.0305 .

Gnathosoma: Hypostome with about 8 short apical nude setae. Cheliceral base normal, punctate; blade narrowed, elongated but shearlike, with about 10 teeth. Cheliceral measurements (means of 10 specimens); BL: 71.6 ± 1.845 , BH: 28.7 ± 0.7000 , CL: 30.6 ± 0.5927 , BL/BH: 2.51 ± 0.0781 , BL/CL: 2.36 ± 0.0851 . Palpus with claw very elongated, dorsal tibial seta heavy; lower accessory claw absent, apparently replaced by branched body seta; upper accessory claw normal; tarsala about 8 μ long; most tarsal setae nude, rather thick; tarsus with apical nude seta elongated, on outer surface. Setal counts; femur (8 specimens): 3.38 ± 0.1813 , genu (9 specimens): 7.83 ± 0.2041 , tibia: range 3-5, tarsus, range 7-9.

Scutum: Tectum nearly square. Sensillary area with basal plate rather distinctive; ridges weak but obvious, lending reniform ap-

pearance to area; bulla small and square; sensilla thick, somewhat expanded in midregions, with numerous spinelike branches. Scutal measurements (means of 9 specimens); ASL: 62.3 ± 0.6872 , SB: 28.7 ± 2.0178 , TS: 44.1 ± 1.2427 , SENS: about 90, ASL/SB: 2.17 ± 0.0532 .

Remarks.—*Neoschöngastia americana* appears to be a widespread species in the southeastern United States and in other areas. Most of the hosts of this species are birds; however, Loomis (1956:1355) shows that cottontails are a very important host animal. Loomis also presents evidence to show that the postlarvae probably inhabit soils which are well drained, warm to hot and dry.

Larvae of *N. americana* and *N. brennani* are quite similar, but nymphs of these species differ in several characters, as indicated in the key. Differences between the two species were first observed in the nymphal stage by L. J. Lipovsky. Wharton and Hardcastle (1946:313) describe a nymph which is either that of *N. americana solomonis* or of *N. monticola*. There are numerous differences between their description and the nymph of *N. americana*. Probably the nymph pertains to *N. monticola*; if it is indeed the nymph of *N. a. solomonis*, then *solomonis* should be considered a distinct species.

Neoschöngastia americana proved very difficult to culture. Moderate success was achieved in culture tubes which were allowed to remain much drier than usual. The nymphs ate active stages of collembolans, but ignored their eggs.

Specimens examined.—Total 38 nymphs, as follows: KANSAS. Douglas County: Lawrence, *Sylvilagus floridanus*, July 11, 1949 (10 nymphs, reared LJL), and *Colinus virginianus*, September 15, 1952 (10 nymphs, reared RBL-DAC); 4 mi. S Lawrence, *Sylvilagus floridanus*, July 25, 1948 (2 nymphs, reared LJL); 5 mi. S Lawrence, *Sylvilagus floridanus*, July 14, 1948 (16 nymphs, reared LJL).

Neoschöngastia brennani Crossley and Loomis

(Figs. 11, 41, 72, 100, 101, 149)

Neoschöngastia brennani Crossley and Loomis, 1955, Ent. News, vol. 66, pp. 114-117 (larva).

Description of nymph.—Resembles *N. americana* except as follows:

Body: About 0.6 mm. long. Setae with somewhat longer branches; posterior setae about 70 μ long. Precoxal plates with each plate bearing about 8 setae. Measurements of tarsus I (means of

2 specimens); TL: 91.5 ± 3.50 , TH: 44.5 ± 0.50 , TL/TH: 2.05 ± 0.050 .

Gnathosoma: Hypostome with about 8 very short apical nude setae. Cheliceral blade without teeth. Cheliceral measurements (means of 2 specimens); BL: 94.5 ± 0.50 , BH: 34.5 ± 2.50 , CL: 36.5 ± 1.50 , BL/BH: 2.8 ± 0.250 , BL/CL: 2.6 ± 0.140 . Palpus with lower accessory claw present but small; tarsala about 7μ long. Setal counts (means of 2 specimens); femur: 3.5 ± 0.000 , genu: 10.25 ± 1.2502 , tibia: 3 (all on outer surface), tarsus: range 8-9.

Scutum: Sensilla thick, not expanded in midregions. flexible; with long branches restricted to distal thirds. Scutal measurements (means of 2 specimens); ASL: 66.0 ± 8.000 , SB: 34.0 ± 3.00 , TS: 38.0 ± 0.00 , SENS: about 115, ASL/SB: 1.95 ± 0.500 .

Remarks.—Loomis (1956:1359) notes that this species is known only from birds, particularly the woodpecker, *Melanerpes erythrocephalus*, and suggests that postlarvae may inhabit standing or fallen dead trees.

Specimens examined.—Total 2 nymphs, as follows: KANSAS. Barber County: $10\frac{1}{2}$ mi. W Hardtner, *Melanerpes erythrocephalus*, July 26, 1952 (2 nymphs, reared DAC).

Genus *Pseudoschöngastia* Lipovsky

Pseudoschöngastia Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, p. 95 (type *Pseudoschöngastia hungerfordi* Lipovsky) (larva).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, not expanded, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome short, blunt; with about twenty short apical nude or nearly nude setae. (9) Pharynx marked with a reticulate pattern. (10) Tectum broad, hyaline, with smooth margin; with one small tectal seta. (11) Sensillary area wide, mean ratio ASL/SB: about 1.7. (12) Without branched body seta in sensillary area. (13) Sensilla straight, rather thick to subclavate, with branches.

Additional features (nymph).—(14) Body medium in size (about 0.6 mm. long), elongated. (15) Sternum broadly pentagonal, closed behind. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli posterior; base with posterior tip depressed. (18) Palpus stout, small; distal portion of tibia not

unusually elongated; claw slightly curved, moderate in size; two accessory claws; tarsus with four to seven branched setae and *two apical nude setae*. (19) Hypostome with about ten ventral branched setae. (20) Basis capituli short, broad. (21) Crista short, narrow. (22) Sensillary area with basal plate of two well-separated halves; bulla rather large; carina absent; sensillary bases placed well laterally; anterior, lateral, and posterior ridges weak; ridges medial to sensillary bases absent; apodeme apparently absent. (23) About ten parascutal setae.

Remarks.—*Pseudoschöngastia* is separable from, but closely related to, *Euschöngastoides*. Also, its relationship to *Walchia* and to *Schoutedenichia* is evidenced by several characters. Audy (1954: 155) suggests that *Pseudoschöngastia* is really related to *Euschöngastia*, an opinion which I do not share. However, Audy may be considering as typical *Euschöngastia* certain species which would better be accommodated in *Euschöngastoides*.

Larvae of *Pseudoschöngastia* are recognized by the posterolateral scutal setae being displaced from the scutum and the legs II and III having their femurs undivided. Otherwise, they also show similarities to larvae of *Euschöngastoides*.

In culture, both species of *Pseudoschöngastia* eat active stages of collembolans rather than their eggs.

KEY TO SPECIES OF PSEUDOSCHÖNGASTIA (NYMPHS)

1. Reticulate markings cover about half the width of the pharynx; cheliceral blade with about 6 large conspicuous teeth; sensilla straight, never expanded *farneri* p. 237
- 1'. Reticulate markings restricted to midline of pharynx; cheliceral blade with about 10 small teeth; sensilla straight, usually somewhat expanded but occasionally not *hungerfordi* p. 236

Pseudoschöngastia hungerfordi Lipovsky

(Figs. 32, 91, 144, 218)

Pseudoschöngastia hungerfordi Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, pp. 95-99 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color white. Setae short, with long branches; tips of posterior setae composed of 2-3 rather long branches; posterior setae about 20 μ long. Sternum closed behind, roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 9 specimens); TL: 88.1 ± 2.300 , TH: 52.1 ± 1.263 , TL/TH: 1.70 ± 0.0373 .

Gnathosoma: Reticulate markings on pharynx restricted to midline. Cheliceral base stout, puncta apparently absent; blade shear-like, with about 10 small teeth covering most of dorsal margin;

occasional specimens with fewer (about 8) larger teeth. Cheliceral measurements (means of 8 specimens); BL: 44.5 ± 2.535 , BH: 23.3 ± 0.974 , CL: 26.6 ± 0.681 , BL/BH: 2.01 ± 0.106 , BL/CL: 1.76 ± 0.0906 . Palpus stout, small, accessory claws thin; tarsala about 7μ long; tarsus with one inner and one outer apical nude seta. Setal counts (means of 8 specimens); femur: 3.00 ± 0.125 , genu: 4.10 ± 0.164 , tibia: range 2-3, tarsus: range 4-6.

Scutum: Tectal seta small and with few branches (about 4). Sensillary area with bulla triangular; sensilla stiff, usually somewhat expanded and nearly subclavate, rarely unexpanded, with short branches on basal thirds, long straight thick-based branches on midregions, and shorter but similar branches on apical thirds. Scutal measurements (means of 10 specimens); ASL: 55.3 ± 0.9781 , SB: 32.3 ± 0.6047 , TS: 6.75 ± 0.250 , SENS: about 80, ASL/SB: 1.69 ± 0.0378 .

Remarks.—The characters in the key separate most specimens of *P. hungerfordi* from *P. farneri*. Several poorly mounted specimens could not be placed satisfactorily in one species or the other.

Pseudoschöngastia hungerfordi was readily cultured, and a number of adults were so obtained.

Specimens examined.—Total 149 nymphs, as follows: KANSAS. Barber County: 3 mi. S Aetna, *Neotoma micropus*, July 25, 1952 (5 nymphs, reared DAC); 4 mi. S Aetna, *Neotoma micropus*, July 11, 1955 (7 nymphs, reared DAC, idet. by larval skins), and August 22, 1949 (46 nymphs, reared LJL); 5 mi. S, 3 mi. E Aetna, *Neotoma micropus*, July 25, 1952 (2 nymphs, reared DAC). Douglas County: 5 mi. S Lawrence, *Sylvilagus floridanus*, July 14, 1948 (10 nymphs, reared LJL). Greenwood County: $1\frac{1}{2}$ mi. E Hamilton, *Neotoma floridana*, August 14, 1949 (46 nymphs, reared LJL). Rawlins County: 9 mi. W Atwood, *Reithrodontomys megalotis*, August 10, 1949 (2 nymphs, reared LJL). TEXAS. Bexar County: Camp Bullis, *Sylvilagus auduboni*, April 25, 1954 (31 nymphs, reared RBL-DAC).

Pseudoschöngastia farneri Lipovsky

(Figs. 33, 90, 124, 125, 145)

Pseudoschöngastia farneri Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, pp. 101-102 (larva).

Description of nymph.—Resembles *P. hungerfordi* except as follows:

Body: Measurements of tarsus I (means of 9 specimens); TL: 90.0 ± 2.06 , TH: 48.9 ± 1.07 , TL/TH: 1.88 ± 0.0325 .

Gnathosoma: Reticulate markings covering about half the width of the pharynx. Cheliceral blade with about 6 larger conspicuous teeth; sometimes with more (about 8) teeth. Cheliceral measurements (means of 9 specimens); BL: 55.8 ± 0.7412 , BH: 29.4 ± 0.7287 , CL: 29.9 ± 0.5880 , BL/BH: 1.91 ± 0.2609 , BL/CL: 1.88 ± 0.2146 . Setal counts of palpus (means of 9 specimens); femur: 2.89 ± 0.139 , genu: 6.17 ± 0.238 , tibia: range 3-4, tarsus: range 4-7.

Scutum: Sensilla like those of *P. hungerfordi* but never expanded. Scutal measurements (means of 9 specimens); ASL: 54.3 ± 1.10 , SB: 32.7 ± 1.146 , TS: 6.25 ± 0.500 , SENS: about 70, ASL/SB: 1.69 ± 0.0696 .

Remarks.—Unlike *P. hungerfordi*, *P. farneri* was very difficult to maintain in culture. This suggests that *P. farneri* has different requirements, which were not met in the cultures. Loomis (1956: 1350) suggests, however, that these two species are probably often in direct competition as postlarvae, since they frequently occur on the same host and have about the same range of host species.

Specimens examined.—Total 13 nymphs, as follows: KANSAS. *Barber County*: 3 mi. S Aetna, *Neotoma micropus*, July 25, 1952 (2 nymphs, reared DAC); 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (1 nymph, reared LJL); 4 mi. S Aetna, *Neotoma micropus*, July 11, 1955 (4 nymphs, reared DAC, idet. by larval skins). *Lyon County*: 2 mi. S Chalk, *Perognathus hispidus*, May 31, 1950 (1 nymph, reared LJL). *Russell County*: 9 mi. S Russell, *Peromyscus maniculatus*, April 26, 1952 (4 nymphs, reared DAC); 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus*, April 27, 1952 (1 nymph, reared DAC).

Genus *Speleocola* Lipovsky

Speleocola Lipovsky, 1952, Jour. Kansas Ent. Soc., vol. 25, p. 134 (type *Speleocola tadaridae* Lipovsky) (*larva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 147 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1326 (*larva*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates of coxa I absent. (3) Body setae short, not expanded; *with compound branching*; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) *Cheliceral base unusually elongated* (ratio BL/BH: about 3.5); blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting, with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum small, hyaline, margin

with teeth; with one tectal seta. (11) Sensillary area triangular; ratio ASL/SB: about 2.5. (12) Without branched body seta in sensillary area. (13) Sensilla subclavate; branches short with heavy bases.

Additional features (nymph).—(14) Body small (about 0.4 mm. long). (15) Sternum not closed behind, somewhat elongated. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; posterior tip of cheliceral base depressed. (18) Palpus somewhat elongated, size small; distal portion of tibia not unusually elongated; claw slightly curved, somewhat elongated; two accessory claws; tarsus with about nine nude or nearly nude setae and three apical nude setae. (19) Hypostome with about ten ventral branched setae. (20) *Basis capituli elongated*. (21) Crista a narrow rod. (22) Sensillary area with basal plate of two halves; bulla reduced in size; carina present; sensillary bases placed well lateral; anterior and lateral ridges strong but posterior ridge weak; *ridges medial to sensillary bases bearing small carinae*; apodeme normal. (23) About eight parascutal setae.

Remarks.—*Speleocola* is monotypic for *S. tadaridae*. As a larva this species has a peculiar scutum and particularly peculiar sensilla. The sensilla are apparently unexpanded but the branches are broad based and leaflike, possibly producing the effect of an expanded sensillum.

The nymphs of *S. tadaridae* are quite similar to those of *Trombicula* species. The outstanding differences are the compound branching of the body setae and the carinate ridges medial to the sensillary bases. Whether or not these differences are sufficient to merit the generic distinction is a debatable question.

Speleocola tadaridae Lipovsky

(Figs. 39, 86, 128, 129, 173, 233)

Speleocola tadaridae Lipovsky, 1952, Jour. Kansas Ent. Soc., vol. 25, pp. 134-137 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1326-1327 (*larva*).

Description of nymph.—Body: About 0.4 mm. long, color not known. Setae short, with few branches further dissected into 2-4 compound branches; posterior setae about 12 μ long. Sternum with about 4 setae. Measurements of tarsus I (means of 10 specimens); TL: 63.8 ± 0.442 , TH: 28.4 ± 0.371 , TL/TH: 2.25 ± 0.0428 .

Gnathosoma: Cheliceral base slightly curved, elongated, area of articulation covering about two-thirds of ventral margin, base punctate; blade shearlike, rather elongated, with about 16 tiny

teeth. Cheliceral measurements (means of 10 specimens) BL: 91.7 ± 0.8172 , BH: 26.6 ± 0.6531 , CL: 37.4 ± 0.5413 , BL/BH: 3.46 ± 0.0670 , BL/CL: 2.45 ± 0.0268 . Palpus small, with reduced setation, and setae with reduced branching; dorsal setae of genu and tibia nude or nearly so; tibial seta at inner tarsal articulation nude; claw and accessory claws slender; tarsala about 4 μ long; tarsus with 2 inner, 1 outer apical nude setae. Setal counts (means of 10 specimens); femur: 3.45 ± 0.279 , genu: 3.25 ± 0.1535 , tibia: range 4-5, tarsus: range 7-9.

Scutum: Tectum rather rounded; marginal teeth conspicuous; seta near end of crista. Sensillary area with basal plate rather small; apodeme present, normal, hard to see; bulla triangular and small; carina thin; "saddle" portion of area large, punctate; sensilla expanded, with numerous short spinelike branches. Scutal measurements (means of 10 specimens); ASL: 54.9 ± 0.8175 , SB: 22.4 ± 0.4521 , TS: 14.4 ± 0.1633 , SENS: about 55, ASL/SB: 2.45 ± 0.0342 .

Remarks.—This species was reared on a single occasion by L. J. Lipovsky. The nymphs did not eat, and none reached the adult stage.

Specimens examined.—Total 23 nymphs, as follows: OKLAHOMA. Woods County: 6 mi. S, 2 mi. W Aetna, Kans., *Tadarida mexicana*, August 24, 1949 (23 nymphs, reared LJJL).

Genus *Trombicula* Berlese

Trombicula Berlese, 1905, Redia, vol. 2, p. 155 (type *Trombicula minor* Berlese) (*adult*); Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 73 (*part*) (*adult*); Ewing, 1949, Jour. Washington Acad. Sci., vol. 39, p. 235 (*adult*); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 326 (*adult*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 137 (*adult*).

Diagnosis (nymph).—(1) Eyes absent or 1/1 and adjacent to sensillary area. (2) Precoxal plates of coxae I absent or fused in midline to form longitudinally divided sternum. (3) Body setae variable, branched, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base rarely unusually elongated (mean ratio BL/BH: up to 3.6); blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting; with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum square to triangular, hyaline, margin with teeth; with one tectal seta. (11) Sensillary area triangular;

mean ratio ASL/SB: about 2.0-2.7. (12) Without branched body seta in sensillary area. (13) Sensilla variable, flagelliform to subclavate, with at least basal branches.

Additional features (nymphi).—(14) Body small to large (about 0.5-1.0 mm. long), sometimes elongated. (15) Sternum nearly rectangular when longitudinally divided; otherwise open or closed behind and elongated to roughly pentagonal. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; posterior tip of cheliceral base depressed. (18) Palpus stout to somewhat elongated; distal portion of tibia not unusually elongated; two accessory claws; tarsus with about nine branched setae and three to six apical nude setae. (19) Hypostome with about ten to twenty ventral branched setae. (20) Shape of basis capituli variable. (21) Crista a narrow to very narrow rod. (22) Sensillary area with basal plate of two halves, variable; bulla usually large, sometimes reduced; carina present or absent; sensillary bases placed well lateral; anterior, lateral, and posterior ridges present but variable; often additional ridges present; apodeme present, well developed to reduced. (23) About eight to thirty parascutal setae.

Remarks.—In addition to the species described in the present paper, postlarvae of about sixty species of *Trombicula* have been previously described; these are discussed under the appropriate subgenera. Most of the descriptions are inadequate but to my knowledge none will be excluded from the genus by my diagnosis. It should be noted, however, that the foregoing diagnosis is very broad. Many previously described forms are known only as adults; their placement is questionable. I feel that they should be left in *Trombicula* until they can be definitely placed.

The type of the genus, *Trombicula minor* Berlese, is known from the original description of Berlese and a redescription of several years later; Willmann in 1941 redescribed the types which were subsequently destroyed by war. The type locality is a rather inaccessible bat cave in Java; it has not been possible to collect topotypical material. This mite has been the subject of much discussion which I will not attempt to summarize; this has been done by Womersley (1952:328-330) and by Audy (1954:138-140). I shall attempt to list what definite information we do have concerning *T. minor*. (1) The types were adults (as shown by Willmann) and almost certainly trombiculids. (2) The adults were small, even for trombiculids. (3) The presence of these mites

in bat caves strongly suggests that the larvae are parasites of bats, but this is not certain. (4) In the way of descriptive material we have the brief descriptions of Berlese and of Willmann, and illustrations of scuta and palpi by these authors. (5) It seems safe to assume that if *T. minor* possesses any strikingly unusual features these would have been detected by either Berlese or Willmann.

The descriptions are quite brief. The illustrations of palpi are difficult to evaluate; the palpi were drawn in a half-turned position and it seems to me that they could represent almost any trombiculid. The illustrations of the scutum by Berlese are poor; the illustration by Willmann is better but is obviously diagrammatic. Authors have been unable to agree as to whether Willmann's drawing of the sensillary area showed enlarged sensillary bases or eyes adjacent to the scutum (Willmann himself was uncertain on this point). While Willmann's illustration appears to me to show a *Trombicula* or *Euschöngastia* sensillary area, I believe that with a slight stretch of the imagination it could be fitted to several other genera.

From these considerations I draw the following conclusions. (1) It is almost a certainty that *T. minor* is a small trombiculid. (2) It is highly probable that the larvae are parasites of bats. (3) It is possible that *T. minor* is a member of the genus *Trombicula* as currently understood, but it could easily be considered congeneric with species now placed in different genera. (4) It will be impossible to recognize *T. minor* on the basis of the existing descriptions.

As type of the genus *Trombicula*, *T. minor* is bound to continue to cause taxonomic indecision and confusion. One acceptable solution would be to restrict *Trombicula* to *T. minor* and remove all other species to a different genus (or genera). Concerning this course, Wharton and Fuller (1951:42) write, "Such a course would be entirely unjustified, since, despite the plethora of generic names that have been proposed, *Trombicula* as understood here is no broader in its content than are such genera as *Neoschöngastia* and *Euschöngastia*. In handling nomenclatorial problems of this kind stability should be maintained if it is at all possible to do so and still remain in agreement with the known biological facts." This conservative course has so far been more productive than the alternative would be. However, the genus *Trombicula* has become unwieldy, not through the number of species it contains but through their diversity. At present the revision of this genus would constitute a very difficult task, and as more species which key out to *Trombicula* are added, the difficulties will increase. It seems to

me that the best course would be to appeal to the International Commission of Zoological Nomenclature to use its plenary powers to stabilize the genus *Trombicula*, by replacement of the type *T. minor* with some well-known species. I would suggest that the species selected be a bat parasite in the Asiatic-Pacific area.

The genus *Trombicula* has been divided into several subgenera; there are more or less distinct groups of species which have been left in *Trombicula* primarily because they are possibly congeneric with *T. minor*. Included in this paper are representatives of *Eutrombicula*, *Neotrombicula*, and *Leptotrombidium*, plus species which fall into no well defined subgenus and are therefore customarily placed in the subgenus *Trombicula*. These subgenera will be discussed further under their headings.

As a genus, *Trombicula* as understood here is close to the genera *Speleocola*, *Blankaartia*, and *Euschöngastia*. *Speleocola* (monotypic) may well be an aberrant *Trombicula*. *Blankaartia* has primitive characteristics but is nevertheless similar to some species of *Trombicula*. *Euschöngastia* is separable from *Trombicula* in both larval and postlarval stages on single characters; *Trombicula* larvae have unexpanded sensilla and nymphs have teeth on the tectal margin, while *Euschöngastia* larvae have expanded sensilla and have a smooth tectal margin. Otherwise the genera have some species which appear similar and it may become increasingly difficult to separate these two genera as they are currently understood.

KEY TO SPECIES OF TROMBICULA (NYMPHS)

- 1. Eyes present adjacent to sensillary area; posterior scutal ridge with two strong elevations medial to sensillary bases
 (subgenus *Eutrombicula*) 2
- 1'. Eyes absent; posterior scutal ridge without elevations or with only very weak elevations 5
- 2. Posterior body setae with tips rounded, slightly expanded, bearing many short branches *belkini* p. 248
- 2' Posterior body setae tapering gradually, ending in 2-3 short branches 3
- 3. Smaller; mean ASL about 90 μ , individual ASL less than 100 μ .
alfreddugèsi p. 245
- 3'. Larger; mean ASL about 115 μ or more, individual ASL more than 100 μ 4
- 4. Posterior body setae mostly ending in two tiny branches, but some ending in three *lipovskyana* p. 249
- 4'. Posterior body setae mostly ending in three tiny branches, but some ending in two *splendens* p. 250
- 5. Precoxal plates of coxae I present and fused medially to form a longitudinally divided sternum
 (Subgenus *Leptotrombidium*) *myotis* p. 257

5. Precoxal plates of coxae I absent 6
6. Palpal tarsus with three apical nude setae (subgenus *Trombicula*, part) 7
- 6'. Palpal tarsus with more than three apical nude setae 10
7. Cheliceral base unusually elongated (mean ratio BL/BH: 3.6) *ornata* p. 267
- 7'. Cheliceral base not unusually elongated (mean ratio BL/BH: less than 3.0) 8
8. Posterior body setae shorter, about 15 μ long *merrihewi* p. 264
- 8'. Posterior body setae longer, about 20-25 μ 9
9. Smaller species; ASL about 59 μ *crossleyi* p. 258
- 9'. Larger species; ASL about 66 μ *trisetica* p. 268
10. Palpal tarsus with four apical nude setae (*T.*) *montanensis* p. 265
- 10'. Palpal tarsus with five or six apical nude setae 11
11. Sensilla nude except for short basal branches; rarely furcate at tips (*N.*) *whartoni* p. 255
- 11'. Sensilla with at least several distal branches in addition to small basal branches 12
12. Sensilla flagelliform, very flexible, scarcely thicker than branches; branches long (subgenus *Trombicula*, part) 13
- 12'. Sensilla flexible but thickened, much thicker than branches; branches usually shorter 14
13. Cheliceral base unusually elongated (BL/BH: 3.0) *kansasensis* p. 262
- 13'. Cheliceral base not unusually elongated (mean ratio BL/BH: 2.6) *gurneyi* p. 261
14. Apical third of posterior body seta with many very short branches; longer branches mostly restricted to basal portion
(subgenus *Trombicula*, part) 15
- 14'. Posterior body seta normal, not so modified
(subgenus *Neotrombicula*, part) 16
15. Occasional long branches on apical third of posterior body seta *kardosi* p. 263
- 15'. Longer branches entirely restricted to basal portion of posterior body seta *fitchi* p. 260
16. Smaller species; mean ASL about 65 μ *sylvilagi* p. 254
- 16'. Larger species; mean ASL about 84.97 μ 17
17. Posterior body setae longer (about 70 μ) *autumnalis* p. 252
- 17'. Posterior body setae shorter (about 45 μ) *lipovskyi* p. 253

Subgenus *Eutrombicula* Ewing

Eutrombicula Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 293 (type *Microtrombidium alfreddugèsi* Oudemans) (*larva*).
Trombicula (*Eutrombicula*), Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, pp. 289-317 (*postlarvae*).

Diagnosis (nymph).—(1) Eyes 1/1, adjacent to sensillary area. (10) Tectum square, with numerous small teeth on margin. (22) Sensillary area with posterior scutal ridge with two strong elevations medial to sensillary bases. (23) About twenty to thirty parascutal setae.

Remarks.—This subgenus could easily be raised to generic rank. I have not done so, for two reasons: One, despite differences. *Eutrombicula* species are very close to some other species of *Trombicula* (for example, *T. gurneyi*); and two, species in the Asiatic-Pacific area require re-examination (see Audy 1954:146). Of the subgeneric characters the presence of eyes adjacent to the sensillary area is probably the most important. However, it should be pointed out that the eyes of *T. belkini* were seen on but one specimen. Also, *T. frittsi* Wharton appears to have eyes in this position (nymph described by Womersley, 1952, p. 330) but otherwise does not seem to be a *Eutrombicula*. Nevertheless, I am inclined to look upon any nymph with eyes in this position as very probably being a member of this subgenus. In culture, nymphs readily ate Collembola eggs. Adults were obtained of all four species cultured.

Other postlarvae of *Eutrombicula* have been described. The species *T. coarctata* Berlese, *T. manriquei* Ewing, and *T. mediocris* Berlese are known as adults only. Nymphs of *T. hirsti* Sambon and *T. sarcina* Womersley have been described. Both nymphs and adults of *T. batatas* (Linnaeus), *T. samboni* Womersley, and *T. wichmanni* (Oudemans) have been described. I have not been able to construct a key to handle these forms; the included key contains only the species I have actually examined. Womersley (1952:325) considers Willmann's drawing of *T. minor* to exhibit eyes; therefore he considers *Eutrombicula* a synonym of *Trombicula* (*Trombicula*). While this is possible, I prefer to follow the interpretation of Ewing and others that the illustration shows enlarged sensillary bases rather than eyes.

Trombicula alfreddugèsi (Oudemans)

(Figs. 21, 74, 110, 111, 168, 191, 226, 227)

- Microthrombidium alfreddugèsi* (Oudemans), 1910, Ent. Berichten, vol. 3, p. 84 (*larva*).
Eutrombicula alfreddugèsi, Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 294 (*larva*).
Trombicula (*Eutrombicula*) *alfreddugèsi*, Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, p. 306 (*adult*); Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, pp. 652-654 (*postlarvae*).
Trombicula (*Trombicula*) *alfreddugèsi*, Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 333.
Trombicula irritans, Ewing, 1929, Manual of External Parasites, p. 23 (*adult*).
Trombicula cinnabaris Ewing, 1921, Ann. Ent. Soc. America, vol. 13, p. 387 (*adult*).
Eutrombicula vanommereni, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 414 (*postlarvae*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 332.

Description of nymph.—Body: About 0.9 mm. long engorged, rather rounded posteriorly, color orange to red. Eyes rounded,

red, closely adjacent to sensillary area, about 17μ in diameter. Setae long, stems thick but tapered, with many fine branches; tips of posterior body setae with 2, rarely 3, short branches; posterior setae about 60μ long. Sternum closed behind, roughly pentagonal in shape, with about 8 setae. Measurements of tarsus I (means of 20 specimens); TL: 120.0 ± 2.028 , TH: 65.1 ± 0.8032 , TL/TH: 1.85 ± 0.0246 .

Gnathosoma: Chelicerae of usual facies; base punctate; blade with about 20 teeth of various sizes. Cheliceral measurements (means of 16 specimens); BL: 107.2 ± 2.049 , BH: 46.6 ± 0.8803 , CL: 61.9 ± 1.3735 , BL/BH: 2.28 ± 0.0393 , BL/CL: 1.68 ± 0.0542 . Palpus of usual shape, except femur unusually stout; tarsala about 12μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 9 specimens); femur: $5:61 \pm 0.2324$, genu: $10:56 \pm 0.3783$, tibia: range 4-5, tarsus: range 9-10.

Scutum: Tectum about square, margin with about 20 small teeth. Sensillary area with basal plate of two widely separated bands; apodeme conspicuous; ridges strong; ridges medial to sensillary bases elevated and joining posterior margin to give posterior portion of sensillary area a "bilobed" appearance; bulla triangular, punctate, rather prominent; carina usually doubled, rather thick, prominent; sensilla flagelliform, elongate, with short basal branches and long attenuate distal branches; distal portions unipectinate. Parascutal setae numerous, about 20-30. Scutal measurements (means of 21 specimens); ASL: 88.1 ± 1.273 , SB: 34.3 ± 0.4660 , TS: 34.5 ± 0.5986 , SENS: about 130, ASL/SB: 2.58 ± 0.0318 .

Remarks.—The synonymy given is far from complete, but the important postlarval descriptions are included.

Trombicula alfreddugèsi has been the object of some concentrated studies. Most recently, Loomis (1956:1259-1280) presented evidence on the factors influencing the abundance of larval *T. alfreddugèsi* on hosts. Some discussion was devoted to the postlarval habitat. Evidently postlarvae normally inhabit grassy soil, particularly in the more open areas. Although most trombiculids have not been collected as postlarvae, nymphs and adults of *T. alfreddugèsi* are frequently found beneath limestone rocks and in soil samples during the spring and early summer. Apparently they overwinter as postlarvae.

This species is not strikingly distinct from the two other species of *Trombicula* (*Eutrombicula*) found in eastern Kansas. However, by characters related to their smaller size, nymphs of *T. alfred-*

dugèsi are more readily separable from *T. lipovskyana* and *T. splendens* than those two species are separable from each other.

Trombicula alfreddugèsi is a very common parasite upon many species of both birds and mammals, and is found throughout most of the United States. Among the nymphs available for study, specimens from western Kansas and northern Texas were significantly smaller in the measurement ASL than specimens from eastern Kansas. No other differences were noted between specimens from these areas.

Specimens examined.—Total 159 nymphs, as follows: KANSAS. *Anderson County*: 3 mi. N Garnett, *Crotaphytus collaris*, July 8, 1948 (7 nymphs, reared LJL). *Barber County*: 4 mi. S Aetna, *Neotoma micropus*, August 22, 1949 (39 nymphs, reared LJL), July 25, 1952 (2 nymphs, reared DAC), and July 11, 1955 (15 nymphs, reared DAC, idet. by larval skins), and *Sylvilagus floridanus*, September 14, 1953 (7 nymphs, reared DAC); 5 mi. S Sun City, *Neotoma micropus*, September 14, 1948 (2 nymphs, reared LJL); 3 mi. S Aetna, *Neotoma micropus*, July 25, 1952 (2 nymphs, reared DAC); 10½ mi. W Hardtner, *Sylvilagus floridanus*, July 25, 1952 (2 nymphs, reared DAC). *Cheyenne County*: 3 mi. N St. Francis, *Perognathus hispidus*, July 23, 1948 (1 nymph, reared LJL), *Pituophis catenifer*, July 22, 1948 (1 nymph, reared LJL). *Douglas County*: Univ. Kansas Natural History Reservation, *Elaphe obsoleta*, August 10, 1953 (12 nymphs, reared DAC, idet. by larval skins), *Crotaphytus collaris*, June 24, 1950 (6 nymphs, reared LJL),—"soil sample," February 27, 1951 (1 nymph, col. RBL); 3 mi. S, 1 mi. E Lawrence, *Sylvilagus floridanus*, July 14, 1949 (1 nymph, reared LJL); 5 mi. S Lawrence, *Sylvilagus floridanus*, July 14, 1949 (7 nymphs, reared LJL); 4 mi. S Lawrence, *Zenaidura macroura*, July 25, 1948 (1 nymph, reared LJL) and *Colinus virginianus*, July 25, 1948 (4 nymphs, reared LJL); 2 mi. W Lawrence, *Sylvilagus floridanus*, June 19, 1949 (9 nymphs, reared LJL). *Miami County*: Miami Co. State Park, *Agkistrodon contortrix*, October 12, 1948 (1 nymph, reared LJL). *Rawlins County*: 8 mi. S Beardsley, *Perognathus hispidus*, July 29, 1948 (1 nymph, reared LJL), and *Cnemidophorus sexlineatus*, July 29, 1948 (1 nymph, reared LJL). *Seward County*: Liberal, *Dipodomys ordii*, September 8, 1948 (1 nymph, reared LJL); 4 mi. NE Liberal, *Sigmodon hispidus*, September 12, 1948 (24 nymphs, reared LJL); 12 mi. NE Liberal, *Sceloporus undulatus*, September 9, 1948 (1 nymph, reared LJL). *Shawnee County*: 3 mi. W Topeka, *Sylvilagus floridanus*, August 26, 1948 (3 nymphs, reared LJL). NE-

BRASKA. *Webster County*: 3 mi. E Guide Rock, *Heterodon nasicus*, August 5, 1951 (3 nymphs, reared DAC). OKLAHOMA. *Woods County*: 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinus*, October 7, 1951 (1 nymph, reared DAC). TEXAS. *Taylor County*: *Phrynosoma cornutum*, June 10, 1952 (4 nymphs, reared DAC).

Trombicula belkini Gould

(Figs. 23, 79, 229)

Trombicula (Eutrombicula) belkini Gould, 1950, Wasmann Jour. Biol., vol. 8, p. 367 (*larva*).

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 0.7 mm. long, color red. Eyes red, but obscured in mounted materials, detectable by disruption of cuticular striae; about 20 μ in diameter. Setal stem thickened, with many fine branches; tips of posterior setae rounded, slightly expanded, with numerous short branches; posterior setae about 65 μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 6 specimens); TL: 124.5 ± 1.727 , TH: 64.7 ± 0.4216 , TL/TH: 1.92 ± 0.0308 .

Gnathosoma: Cheliceral blade with about 14 teeth. Cheliceral measurements (means of 9 specimens); BL: 114.9 ± 0.8071 , BH: 45.1 ± 0.7349 , CL: 59.9 ± 0.4233 , BL/BH: 2.57 ± 0.0500 , BL/CL: 1.92 ± 0.0147 . Palpus with dorsal femoral setae profusely branched; tarsala about 9 μ long. Setal counts; femur (7 specimens): 7.21 ± 0.2641 , genu (8 specimens): 11.00 ± 0.2631 , tibia: range 5-6, tarsus: range 8-10.

Scutum: Sensilla with branches shorter and more numerous; bipectinate on distal portions. Scutal measurements (means of 6 specimens); ASL: 92.8 ± 0.7492 , SB: 34.3 ± 0.6062 , TS: 33.7 ± 0.9189 , SENS: about 100, ASL/SB: 2.73 ± 0.0616 .

Remarks.—This species is readily separable from other species of *Trombicula (Eutrombicula)* in the nymphal stage by the form of the posterior body setae. Also, the profuse branching of the setae on the palpal femur is a useable character. The eyes are of interest in *T. belkini*; although they were detected in living material by their color, the actual lens was visible on but one mounted specimen. The striae of the cuticle were disrupted in the area adjacent to the sensillary bases, where the lens should be.

Specimens examined.—Total 9 nymphs, as follows: CALIFORNIA. *Marin County: Sceloporus occidentalis*, June 1, 1952 (9 nymphs, reared DAC).

Trombicula lipovskyana Wolfenbarger

(Figs. 25, 76)

Trombicula (Eutrombicula) lipovskyana Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, pp. 660-666 (*larva, postlarva*).

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 1.0 mm. long, color red. Eyes sometimes obscured, about 20 μ in diameter. Posterior body setae slightly shorter, about 50 μ long. Sternum with about 12 setae. Measurements of tarsus I (means of 8 specimens); TL: 149.0 ± 3.742 , TH: 81.3 ± 2.102 , TL/TH: 1.85 ± 0.0191 .

Gnathosoma: Cheliceral blade with about 22 teeth. Cheliceral measurements (means of 10 specimens); BL: 140.0 ± 2.936 , BH: 61.4 ± 0.8326 , CL: 84.4 ± 1.0872 , BL/BH: 2.32 ± 0.0359 , BL/CL: 1.66 ± 0.0276 . Palpus large; tarsala about 13 μ long. Setal counts; femur: 6.5 ± 0.2835 (8 specimens), genu: 14.05 ± 0.3877 (10 specimens), tibia: range 4-6, tarsus: range 8-10.

Scutum: Measurements (means of 10 specimens); ASL: 116.9 ± 1.656 , SB: 47.9 ± 0.8360 , TS: 35.9 ± 2.0911 , SENS: about 140, ASL/SB: 2.44 ± 0.0400 .

Remarks.—As larva, this species is very close to *T. alfreddugèsi*, but as nymph its affinities appear to be with *T. splendens*. Indeed *T. lipovskyana* may be a subspecies of *T. splendens*. The distribution of *T. lipovskyana* is not well known; apparently it is distributed throughout the southeastern United States (see Loomis, 1956:1280). The habitat of the postlarvae is similar to that of *T. alfreddugèsi*, being grassy soil.

Specimens examined.—Total 24 nymphs, as follows: KANSAS. *Douglas County*: 3 mi. S, 1 mi. E Lawrence, *Sylvilagus floridanus*, July 14, 1949 (11 nymphs, reared LJL); 2 mi. W Lawrence, *Sylvilagus floridanus*, June 19, 1949 (7 nymphs, reared LJL). LOUISIANA. *Jefferson Parish: Anolis carolinensis*, April 28, 1954 (2 nymphs, reared RBL-DAC, idet. by larval skins). *Orleans Parish*: 15 mi. NE New Orleans, *Anolis carolinensis*, April 27, 1954 (4 nymphs, reared RBL, 2 idet. by larval skins).

Trombicula splendens Ewing

(Figs. 13-15, 24, 75, 176, 199, 228)

Trombicula splendens Ewing, 1913, Bull. Amer. Mus. Nat. Hist., vol. 32, pp. 113-114 (adult).*Trombicula (Eutrombicula) splendens*, Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, p. 304 (adult); Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, p. 650 (adult).*Trombicula (Trombicula) splendens*, Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 334 (adult).

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 1.0 mm. long, color red (rarely white). Eyes about 20 μ in diameter. Tips of posterior setae usually with 3 short branches, rarely with 2; posterior setae about 60 μ long. Measurements of tarsus I (means of 9 specimens); TL: 142.8 ± 1.793 , TH: 77.1 ± 1.148 , TL/TH: 1.83 ± 0.167 .

Gnathosoma: Cheliceral blade with about 20 teeth. Cheliceral measurements (means of 10 specimens); BL: 140.8 ± 1.332 , BH: 55.9 ± 0.5859 , CL: 77.8 ± 0.7859 , BL/BH: 2.51 ± 0.0348 , BL/CL: 1.81 ± 0.0179 . Palpus large, tarsala about 14 μ long. Setal counts; femur (9 specimens): 5.06 ± 0.2324 , genu (3 specimens): 12.88 ± 0.5774 , tibia: range 5-7, tarsus: range 8-10.

Scutum: Measurements (means of 10 specimens); ASL: 114.6 ± 2.202 , SB: 45.3 ± 2.791 , TS: 44.6 ± 1.248 , SENS: about 140, ASL/SB: 2.53 ± 0.0298 .

Remarks.—As in the case of *T. alfreddugèsi*, the foregoing synonymy contains only the more important references to postlarvae of the species. Womersley's description of the sensilla as nude is at variance with my findings.

This species is known from Kansas from adults only. Adults taken on several occasions in decaying logs in Miami County were identified by larvae obtained in culture as *T. splendens*. Most of the nymphs here described are second generation, being reared in such a culture of materials from Titus County, Texas.

Trombicula splendens was originally described from adults. The proper larval form was associated by Jenkins (1949:201).

Specimens examined.—Total 20 nymphs, as follows: LOUISIANA. *St. Charles Parish*: 17 mi. SW New Orleans, *Agkistrodon piscivorous*, May 1, 1954 (1 nymph, reared RBL, idet. by larval skin).

TEXAS. *Titus County*: 3 mi. NW Talco, March 26, 1951 (Adults taken from decaying logs; second generation nymphs obtained; total 19).

Subgenus *Neotrombicula* Hirst

Neotrombicula Hirst, 1925, *Nature*, vol. 116, p. 609 (type *Acarus autumnalis* Shaw) (*larva*).

Trombicula (*Neotrombicula*), Brennan and Wharton, 1950, *American Midl. Nat.*, vol. 44, p. 156 (*adult*); Philip and Fuller, 1950, *Parasit.*, vol. 40, pp. 54-55 (*postlarvae*); Womersley, 1952, *Rec. South Australian Mus.*, vol. 10, p. 349 (*adult*).

Diagnosis (nymph).—None.

Remarks.—I find no character or group of characters which permit recognition of this subgenus. Therefore it is left without diagnosis in the nymphal stage, although larvae can be recognized.

Certain features of possible subgeneric importance should be mentioned. The four species studied by me have stout cheliceral bases and wide blades, with rather large teeth. The least extreme is *T. autumnalis*, which has chelicerae more similar to those of *Trombicula* (*Eutrombicula*). Sensilla tend to be thickened and provided with small branches (except *T. sylvilagi*). In these features the species resemble some members of *Euschöngastia* more closely than they resemble other species of *Trombicula*. It is interesting to note that in both genera the species so modified are fall and winter chiggers. A better source of group characters for these species appears to be the scutum. The species all have similar scuta but I have not been able to find a character which separates them from nymphs of other *Trombicula* species. A very possible character involves the bulla of the sensillary area, which is somewhat enlarged and either lacks a carina or has a short, thick carina almost indistinguishable from the bulla itself. This single feature would not exclude some other species of *Trombicula* from the subgenus *Neotrombicula*.

Nymphs of at least three species of the subgenus *Neotrombicula* have been previously described. *Trombicula pomeranzevi* Schluger has been described by Sasa. André has described the nymph of *T. autumnalis*. Several descriptions are available of postlarvae of *T. japonica* Tanaka but these are inconsistent; the nymph described by Womersley (1952:318, after Tanaka) is certainly not the same as that described by Sasa (1953:423), as noted by Sasa.

Trombicula autumnalis (Shaw)

(Figs. 52, 82, 157, 236)

Acarus autumnalis Shaw, 1790, *Naturae vivarii* (Nat. Misc.), vol. 2 (no pagination) (*larva*).*Trombicula autumnalis*, Kneissl, 1916, *Zool. Anz.*, vol. 46, p. 253 (*nymph*); Hirst, 1915, *Jour. Econ. Biol.*, vol. 10, p. 73 (*nymph*); Philip and Fuller, 1950, *Parasit.*, vol. 40, p. 55 (*nymph*); Richards, 1950, *Parasit.*, vol. 40, pp. 105, 115 (*postlarvae*); Jones, 1951, *Parasit.*, vol. 41, pp. 241-245 (*postlarvae*); Womersley, 1952, *Rec. South Australian Mus.*, vol. 10, p. 364 (*postlarvae*). *Thrombicula autumnalis*, André, 1929, *Bull. Must. d'Hist. Nat. Paris*, 2e Ser., vol. 1, p. 394 (*adult*); André, 1930, *Mem. Zool. Soc. France*, vol. 29, pp. 39-138 (*postlarvae*); André, 1937, *Bull. Mus. d'Hist. Nat. Paris*, vol. 9, p. 313 (*adult*).

Description of nymph.—Body: Elongated, about 0.7 mm. long, color not known. Setae normal, with long branches; tips composed of 1 or 2 somewhat long branches; posterior setae about 70 μ long. Sternum roughly pentagonal, closed behind, with about 10 setae. Measurements of tarsus I (means of 9 specimens); TL: 154 ± 5.077 , TH: 71.4 ± 1.271 , TL/TH: 2.13 ± 0.0441 .

Gnathosoma: Chelicera nearly of usual shape, perhaps slightly robust; base punctate; blade with about 15 teeth. Cheliceral measurements (means of 10 specimens); BL: 122.4 ± 2.509 , BH: 49.2 ± 0.8138 , CL: 70.5 ± 1.014 , BL/BH: 2.51 ± 0.0568 , BL/CL: 1.73 ± 0.0213 . Palpus somewhat stout, very similar to that of *T. lipovskiyi*; tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 5.17 ± 0.1179 , genu: 8.3 ± 0.2135 , tibia: range 4-5, tarsus: range 9-10.

Scutum: Tectum broad, with about 12 teeth on margin, very irregular. Sensillary area broadly triangular in shape; basal plate of two widely separated bands; apodeme conspicuous; strong ridges anterior and posterior to sensillary bases; ridges medial to sensillary bases very weak, posterior ridge very weak; bulla triangular, short and broad, punctate; carina not seen; sensillary bases rather small; sensilla somewhat thickened, with short branches on basal thirds and longer ones on distal portions. Scutal measurements (means of 9 specimens); ASL: 97.0 ± 4.384 , SB: 44.3 ± 1.476 , TS: 34.9 ± 1.493 , SENS: about 115, ASL/SB: 2.19 ± 0.0423 .

Remarks.—I am indebted to Mr. D. M. Minter for these specimens of *T. autumnalis*.

Trombicula autumnalis is probably the species best known as postlarva, thanks to the careful works of André (particularly the 1930 paper), Richards (1950), and Jones (1951).

Specimens examined.—Total 10 nymphs, as follows: ENGLAND. Kent: Chevenins Park, August-September, 1954, "wild rabbits," (10 nymphs, reared by D. M. Minter; associated with larvae of normal type "B" of Richards).

Trombicula lipovskyi Brennan and Wharton

(Figs. 47, 83, 116, 117, 158, 240)

Trombicula (Neotrombicula) lipovskyi Brennan and Wharton, 1950, American Midl. Nat., vol. 44, p. 177 (*larva*); Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 91-98 (*larva*).

Description of nymph.—Body: Rounded, about 0.6 mm. long, color yellow to orange. Setae with stems slightly thickened, branches fine; tips of posterior setae rounded, with about 3 rather long branches; posterior setae about 45 μ long. Sternum pentagonal, closed behind, with about 6-8 setae. Measurements of tarsus I (means of 10 specimens); TL: 128.9 ± 3.971 , TH: 64.6 ± 1.628 , TL/TH: 2.00 ± 0.0259 .

Gnathosoma: Chelicera with both base and blade robust; base punctate, blade with about 11 teeth of intermediate size. Cheliceral measurements (means of 39 specimens); BL: 117.1 ± 1.135 , TH: 48.9 ± 0.4778 , CL: 64.3 ± 0.4776 , BL/BH: 2.41 ± 0.0275 , BL/CL: 1.83 ± 0.0172 . Palpus of usual shape; claw slightly elongated; tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 4.00 ± 0.4887 , genu: 8.2 ± 0.3092 , tibia: range 3-5, tarsus: range 8-10.

Scutum: Tectum triangular in shape, margin with about 10 teeth. Sensillary area markedly triangular in shape; apodeme conspicuous; ridges rather strong but usually distorted; bulla triangular, prominent, apparently highly arched; carina not seen; sensillary bases of usual size; sensilla somewhat thickened, flexible, with short branches distributed along entire length, with few longer branches near tips; stems often but not always furcate at tips. Scutal measurements (means of 10 specimens); ASL: 83.8 ± 1.373 , SB: 38.1 ± 0.994 , TS: 36.5 ± 1.046 , SENS: about 110, ASL/SB: 2.21 ± 0.0586 .

Remarks.—*Trombicula lipovskyi* was reared to the adult stage. Nymphs ate Collembola eggs.

This species is a common chigger in the eastern part of the Midwest Region. Its closest relative in both larval and nymphal stages appears to be *T. whartoni*.

Specimens examined.—Total 153 nymphs, as follows: KANSAS. Barber County: 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April

11, 1949 (12 nymphs, reared LJL). *Douglas County*: Lawrence, *Microtus ochrogaster*, March 5, 1949 (1 nymph, reared LJL), —*Sigmodon hispidus*, October 15, 1948 (1 nymph, reared LJL), and *Neotoma floridana*, March 30, 1949 (4 nymphs, reared LJL); 3 mi. W Lawrence, *Neotoma floridana*, March 5, 1949 (8 nymphs, reared LJL)—*Sylvilagus floridanus*, November 12, 1949 (46 nymphs, reared LJL); 9 mi. W Lawrence, *Sylvilagus floridanus*, January 2, 1949 (6 nymphs, reared LJL); 4 mi. N, 1 mi. E Lawrence, *Neotoma floridana*, November 26, 1948 (9 nymphs, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Sylvilagus floridanus*, March 3, 1949 (1 nymph, reared LJL), December 4, 1948 (1 nymph, reared LJL), and December 29, 1948 (1 nymph, reared LJL); 3 mi. S Eudora, *Sylvilagus floridanus*, February 17, 1949 (1 nymph, reared LJL); 3 mi. W, 2 mi. S Clinton, *Sylvilagus floridanus*, March 10, 1949 (1 nymph, reared LJL). *Jefferson County*: 6 mi. E Perry, *Neotoma floridana*, December 28, 1948 (3 nymphs, reared LJL); 5½ mi. N, ½ mi. E Lawrence, *Sylvilagus floridanus*, November 21, 1951 (17 nymphs, reared DAC), and November 24, 1951 (4 nymphs, reared DAC). *Johnson County*: 2 mi. N, 1 mi. W Lenexa, *Sylvilagus floridanus*, November 18, 1953 (13 nymphs, reared RBL). *Wyandotte County*: Kansas City, *Sylvilagus floridanus*, October 30, 1953 (1 nymph, reared RBL), and December 21, 1953 (3 nymphs, reared RBL). **OKLAHOMA.** *Woods County*: 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinos*, October 7, 1951 (1 nymph, reared DAC).

Trombicula sylvilagi Brennan and Wharton

(Figs. 53, 160, 237)

Trombicula (Neotrombicula) sylvilagi Brennan and Wharton, 1950, Amer. Midl. Nat., vol. 44, pp. 186-187 (*larva*); Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 103-111 (*larva*).

Description of nymph—Resembles *T. lipovskyi* except as follows:

Body: Elongated, small (0.5 mm. long), color orange. Setae short, stems thick; tips rounded, with 2-3 short branches; posterior setae about 25 μ long. Measurements of tarsus I (means of 5 specimens); TL: 101.4 ± 0.600 , TH: 55.0 ± 0.632 , TL/TH: 1.84 ± 0.0283 .

Gnathosoma: Cheliceral base with conspicuously large puncta; blade with about 10 particularly large teeth. Cheliceral measurements (means of 4 specimens); BL: 85.3 ± 1.315 , BH: 37.5 ± 0.866 , CL: 52.5 ± 1.255 , BL/BH: 2.25 ± 0.0646 , BL/CL: 1.63 ± 0.0629 . Palpus with tarsala about 9 μ long. Setal counts; femur (1 specimen): 3.5, genu (3 specimens): 6.50 ± 0.2887 , tibia: range 4-5, tarsus: 9.

Scutum: Sensilla with short branches on basal thirds, longer ones on distal portions (resembling *T. autumnalis*), stems slightly expanded distally. Scutal measurements (means of 5 specimens); ASL: 65.4 ± 1.0296 , SB: 34.2 ± 0.800 , TS: 14.3 ± 0.4787 , SENS: about 75, ASL/SB: 1.92 ± 0.0490 .

Remarks.—As a larva, this species was listed by Brennan and Wharton as “ungrouped,” since it did not appear closely related to other species in *Neotrombicula*. As a nymph, *T. sylvilagi* is not markedly different from *T. lipovskyi*, except in being smaller. Until more postlarvae of *Neotrombicula* are known, it is not possible to evaluate “groups” of species in *Neotrombicula* except on larval characters.

The specimens studied were reared by Ervin H. Kardos in an unusual manner. Unengorged larvae were obtained with chigger samplers and were then allowed to attach to a laboratory mammal (*Mus*). Nymphs were then obtained from these larvae.

Specimens examined.—Total 5 nymphs, as follows: KANSAS. Douglas County: Univ. Kansas Natural History Reservation, chigger sampler, October 8, 1952 (5 nymphs, reared EHK).

Trombicula whartoni Ewing

(Figs. 51, 80, 159)

Trombicula whartoni Ewing, 1929, Ent. News, vol. 40, p. 296 (larva).

Trombicula (Neotrombicula) whartoni, Brennan and Wharton, 1950, Amer. Midl. Nat., vol. 44, pp. 175-176 (larva); Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 98-102 (larva).

Description of nymph.—Resembles *T. lipovskyi* except as follows:

Body: About 0.7 mm. long. Measurements of tarsus I (means of 9 specimens); TL: 148.2 ± 2.101 , TH: 77.9 ± 1.012 , TL/TH: 1.91 ± 0.0247 .

Gnathosoma: Chelicerae nearly normal in shape, perhaps slightly robust; base with conspicuous puncta; blade with about 15 teeth of intermediate size. Cheliceral measurements (means of 9 specimens); BL: 120.6 ± 1.925 , BH: 47.1 ± 1.181 , CL: 65.9 ± 0.8233 , BL/BH: 2.58 ± 0.0843 , BL/CL: 1.83 ± 0.0211 . Palpus with tarsala about 11 μ long; tarsus with 3 inner, 2-3 outer apical nude setae. Setal counts; femur (6 specimens); 6.00 ± 0.3874 , genu (9 specimens): 10.17 ± 0.4714 , tibia: range 4-6, tarsus: range 10-15.

Scutum: Sensillary area with bulla with conspicuous puncta; sensilla nude except for small basal branches, rarely furcate at tips. Scutal measurements (means of 9 specimens); ASL: 101.9 ± 1.775 , SB: 42.8 ± 1.038 , TS: 40.3 ± 1.291 , SENS: about 145, ASL/SB: 2.41 ± 0.0484 .

Remarks.—The nymph is similar to that of *T. lipovskyi* but is easily differentiated by its nude sensilla. Loomis (1956:1295) suggests that *T. whartoni* seems restricted to deciduous woods and the woodland edge, while *T. lipovskyi* occurs in the drier open grasslands but also in the woodland edge.

Trombicula whartoni was less frequently collected than *T. lipovskyi*, but the difference is not so great as to explain why no *T. whartoni* nymphs appeared in the mixed cultures maintained by L. J. Lipovsky. On the two occasions when the species was successfully cultured, the cultures were pure.

Specimens examined.—Total 9 nymphs, as follows: KANSAS. *Douglas County*: 2 mi. S Warden, *Sciurus niger*, November 28, 1949 (2 nymphs, reared LJL). *Johnson County*: Roeland Park, *Sylvilagus floridanus*, November 4, 1953 (7 nymphs, 1 idet. by larval skin, reared RBL-DAC).

Subgenus *Leptotrombidium* Nagayo, Miyagawa, Mitamura
and Inamura

Leptotrombidium Nagayo *et al.*, 1916, *Dobutsugaku Zasshi*, vol. 28, p. 392 (type *Trombidium akamushi* Brumpt) (*larva*).

Trombicula (Leptotrombidium), Ewing, 1949, *J. Washington Acad. Sci.*, vol. 39, p. 236 (*adult*); Womersley, 1952, *Rec. South Australian Mus.*, vol. 10, p. 326 (*adult*); Sasa, 1953, *Japanese Jour. Exp. Med.*, vol. 23, p. 411 (*post-larvae*); Audy, 1954, *Stud. Inst. Med. Res. Fed. Malaya*, no. 26, p. 140 (*postlarvae*).

Diagnosis (nymph).—(2) Precoxal plates of coxae I present but fused in midline to form longitudinally divided sternum.

Remarks.—This diagnostic feature for *Leptotrombidium* was first used by Womersley; Sasa and Audy have followed his diagnosis and the nymphs described by Sasa agree with it. The nymph of *T. myotis*, described in the present paper, is the seventeenth species of *T. (Leptotrombidium)* to be known in the postlarva stage.

Prior to Womersley's (1952:326) discovery of the divided sternum as a subgeneric feature, the subgenus *Leptotrombidium* was diagnosed on combinations of larval characters. It seems likely that in the future, workers will place more emphasis on the nymphal stage for recognition of this subgenus. *Leptotrombidium* was expanded by Womersley (1952:326) and further expansion was suggested by Audy (1954:140). The limits of the subgenus are certainly vague at present; it seems doubtful that the single diagnostic feature used for the postlarval stages will stand the test of time.

Trombicula myotis Ewing

(Figs. 55, 81, 106, 107, 166, 231)

Trombicula myotis Ewing, 1929, Ent. News, vol. 40, pp. 294-295 (*larva*).*Trombicula (Leptotrombidium) myotis*, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 54 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1287-1288 (*larva*).

Description of nymph.—Body: Rounded posteriorly, about 0.6 mm. long, color not known. Setae long, branches fine; tips of posterior setae spatulate, with several short branches; posterior setae about 60 μ long. Sternal division rarely incomplete; each side with about 4 setae. Measurements of tarsus I (means of 4 specimens); TL: 101.3 ± 0.4787 , TH: 59.8 ± 0.2500 , TL/TH: 1.7 ± 0.000 .

Gnathosoma: Cheliceral base somewhat robust, punctate, area of articulation large; blade shearlike, apodeme of blade not constricted, with about 19 small teeth. Cheliceral measurements (means of 4 specimens); BL: 93.0 ± 1.528 , BH: 37.8 ± 2.462 , CL: 49.8 ± 1.250 , BL/BH: 2.63 ± 0.0885 , BL/CL: 1.83 ± 0.0408 . Palpus of usual shape; tarsala about 11 μ long, claw rather short; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 4 specimens); femur: 4.88 ± 0.0126 , genu: 7.00 ± 0.4787 , tibia; 5, tarsus: 9.

Scutum: Tectum large, square, with about 10 teeth. Crista narrow. Sensillary area broad, oval; basal plate of two rather large halves; apodeme short; strong ridges anterior and posterior to sensillary bases, others very weak; bulla much reduced, triangular; carina broad but short; sensillary bases prominent; sensilla somewhat thickened but flexible, with short branches on basal half, longer ones on distal half, longer branches fine. Scutal measurements (means of 3 specimens); ASL: 80.3 ± 2.028 , SB: 31.3 ± 0.8539 , TS: 29.3 ± 0.3334 , SENS: about 80, ASL/SB: 2.50 ± 0.0577 .

Remarks.—Loomis (1956:1289) suggests that postlarvae of this species are probably inhabitants of decaying wood, and possibly nests of mammals nesting in such places.

The nymph of *T. myotis* cannot be keyed down to species of *T. (Leptotrombidium)* in the key given by Womersley (1952:342). Sasa (1953:411) experienced difficulty in separating his nymphs of Japanese species. I am unable to separate *T. myotis* from the nymphs described by Sasa. It appears that the subgenus *Lep-*

totrombidium is a group of species far more readily separable in the larval stage than in postlarval stages.

Specimens examined.—Total 4 nymphs, as follows: IOWA. *Freemont County*: Waubonsie State Park, 5 mi. S, 2 mi. W. Sidney, *Peromyscus leucopus*, October 10, 1953 (4 nymphs, reared RBL).

Subgenus *Trombicula* Berlese

Trombicula Berlese, 1905, Redia, vol. 2, p. 155 (type *Trombicula minor* Berlese) (*adult*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (10) Tectum square to triangular, with few to many teeth on margin. (22) Sensillary area with posterior scutal ridge without elevations or with only weak elevations. (23) About eight to twelve parascutal setae.

Remarks.—More realistically, this subgenus contains those species which do not fall into the other subgenera. The impossibility of recognizing *T. minor* has been previously discussed; without a usable type species the subgenus can only serve as a catch-all.

About twenty postlarvae which would apparently fall into this subgenus have been described; about ten of these are known as adults only. Inclusion of these forms in the key to species was not feasible.

Trombicula crossleyi Loomis

(Figs. 132, 133, 163)

Trombicula crossleyi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 920-922 (*larva*).

Description of nymph.—Body: Small (about 0.5 mm. long), elongated, color orange to red. Setae somewhat short, stem rather thickened, branches fine and numerous; tips of posterior setae with about 3-5 short branches; posterior setae about 20 μ long. Sternal area elongated posteriorly, rectangular in shape, usually open behind, with about 4 setae. Measurements of tarsus I (means of 10 specimens); TL: 77.0 ± 0.7889 , TH: 36.8 ± 0.3267 , TL/TH: 2.10 ± 0.0298 .

Gnathosoma: Cheliceral base of usual shape, puncta almost absent; blade shearlike, with about 14 rather small teeth. Cheliceral measurements (means of 6 specimens); BL: 81.6 ± 1.70 , BH: 28.4 ± 0.68 , CL: 36.8 ± 0.76 , BL/BH: 2.94 ± 0.093 , BL/CL: 2.26 ± 0.034 . Palpus slightly elongated; dorsal genual setae often nude, claw and accessory claws rather small, tarsala about 6 μ long; tarsus with 2 inner, 1 outer apical nude setae. Setal counts (means of 6 specimens); femur: 3.00 (no variation), genu: 2.83 ± 0.1258 ; tibia: range 4-5, tarsus: range 7-9.

Scutum: Tectal margin with about 10 conspicuous teeth. Sensillary area nearly transverse-oval in appearance; apodeme reduced; ridges weak, usually distorted; bulla triangular; carina small and thin; sensillary bases prominent; a pair of noticeably elongated parascutal setae directly in front of sensillary area; sensilla straight, slightly expanded distally, branches short on basal half, longer on distal half. Scutal measurements (means of 10 specimens); ASL: 59.2 ± 1.083 , SB: 27.3 ± 1.041 , TS: 20.8 ± 0.249 , SENS; about 65, ASL/SB: 2.18 ± 0.1065 .

Remarks.—This species is one of a group which, as nymphs, possesses several key characters apparently associated with somewhat smaller size than most species of *Trombicula*. This group of species contains *T. crossleyi*, *T. trisetica*, *T. merrihewi*, and *T. ornata*; some features distinguishing this group are the presence of but three apical nude setae on the palpal tarsus, usually but three setae on the palpal femur, prominent sensillary bases on the scutum (seemingly a reduction of scutal size rather than enlargement of the sensillary bases), and a tendency towards elongation of one pair of parascutal setae. The larvae of these four species are more diverse; larvae of *T. crossleyi* and *T. trisetica* are similar and are undistinguished *Trombicula* species but larvae of *T. merrihewi* and *T. ornata*, while resembling each other, have distinctive scuta and chelicerae.

It is interesting to note that these four species, although similar in morphology in postlarval stages, seemingly exist in different habitats. Loomis (1956:1322), on the basis of larval host preferences, suggests the habitat of postlarvae of *T. crossleyi* and *T. trisetica* to be standing dead trees, and that of *T. ornata* to be crevices of rock outcroppings and possibly nests of mammals, while *T. merrihewi* is known only from bats and postlarvae are assumed to be cave dwellers. Thus it seems likely that the features common to these species are associated with small size rather than being direct adaptations to specific habitats.

Of the species placed in the subgenus *Trombicula*, these four appear to be the most likely relatives of *Trombicula minor*. This relationship is suggested not only by their small size but by comparison of their scuta with the illustration of that of *T. minor*, as given by Willmann (1940:133). As previously noted, Willmann's drawing is diagrammatic and may not be adequate for such comparison.

Trombicula crossleyi is very similar to *T. trisetica* in both larval and postlarval stages, and eventually the two may prove to be

conspecific. Nymphs are difficult to separate; the only differences found involve measurements.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. Barber County: 10½ mi. W Hardtner, *Melanerpes erythrocephalus*, July 26, 1952 (5 nymphs, reared DAC); 4 mi. S Aetna, *Peromyscus leucopus*, October 7, 1951 (6 nymphs, reared LJL), July 25, 1952 (1 nymph, reared DAC).

Trombicula fitchi Loomis

(Fig. 230)

Trombicula fitchi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 926-928 (larva).

Trombicula (Neotrombicula) fitchi, Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1297-1298 (larva).

Description of nymph.—Body: Rounded, about 0.5 mm. long, color not known. Setae with stems normal, branching distinctive; posterior setae with long fine branches on basal halves but short thick-based branches on distal halves; tips with 2 or 3 short branches; posterior setae about 60 μ long. Sternal area roughly pentagonal in shape, closed behind, with about 8 setae. Measurements of tarsus I (means of 10 specimens); TL: 109 ± 3.157 , TH: 53.5 ± 1.046 , TL/TH: 2.03 ± 0.0423 .

Gnathosoma: Chelicerae of usual shape, base punctate; blade with about 20 rather small teeth. Cheliceral measurements (means of 113 specimens); BL: 111.6 ± 1.819 , BH: 38.4 ± 1.071 , CL: 55.5 ± 1.096 , BL/BH: 2.92 ± 0.0715 , BL/CL: 2.01 ± 0.0265 . Palpi of usual shape, dorsal genual setae occasionally nude; tarsus with tarsala about 8 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 8 specimens); femur: $3:94 \pm 0.2904$, genu: 8.13 ± 0.3239 , tibia: range 2-5, tarsus: range 8-9.

Scutum: Tectum with about 8 teeth on margin. Sensillary area triangular; basal plate of two bands; apodeme well developed; ridges usually distorted but rather strong; bulla triangular, well developed; carina thick, hard to see; sensilla rather thick but flexible, with short branches basally but somewhat larger branches distally; branches generally few, none large. Scutal measurements (means of 10 specimens); ASL: 92.9 ± 1.853 , SB: 35.3 ± 1.033 , TS: 33.7 ± 0.5588 , SENS: about 125, ASL/SB: 2.63 ± 0.0472 .

Remarks.—As nymph, *Trombicula fitchi* is easily recognized by the form of the posterior body setae. Nymphs of *T. kardosi* have similar posterior setae but the two are still sufficiently different to permit easy separation.

Loomis (1956:1290) placed these two species in the subgenus *Neotrombicula* on the basis of larval characteristics. To do so required a broadening of the concept of the subgenus which eliminated the principal key character for the subgenus (the presence of long nude whiplike setae on leg III). In the nymphal as well as in the larval stage, *T. fitchi* and *T. kardosi* appear to me to be related to species of *T. (Neotrombicula)*, as Loomis suggests. However, it is difficult to determine how close this relationship may be. Until more nymphs of species of *T. (Neotrombicula)* are known, I prefer to retain *T. fitchi* and *T. kardosi* in the subgenus *Trombicula*.

Specimens examined.—Total 17 nymphs, as follows: KANSAS. *Barber County*: 3½ mi. S Aetna, *Myotis velifer*, April 10, 1949 (5 nymphs, reared LJL). *Douglas County*: *Sciurus niger*, January 19, 1950 (2 nymphs, reared LJL); 2 mi. S Warden, *Sciurus niger*, November 26-28, 1949 (10 nymphs, reared LJL).

Trombicula gurneyi Ewing

(Figs. 57, 69, 112, 113, 164, 238)

Trombicula gurneyi Ewing, 1937, Proc. Biol. Soc. Washington, vol. 50, p. 169 (*larva*); Loomis, 1955, Univ. Kansas Sci. Bull., vol. 37, pp. 252-257 (*larva*).

Description of nymph.—Body: Rounded, about 0.6 mm. long, color red to orange. Setae somewhat short, stems rather thickened, branches fine and numerous; tips of posterior setae with about 3 short branches; posterior setae about 30 μ long. Sternum closed behind, roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 11 specimens); TL: 103.0 ± 3.555 , TH: 53.4 ± 1.330 , TL/TH: 1.93 ± 0.0557 .

Gnathosoma: Cheliceral base of usual shape, puncta few; blade shearlike, with about 16 teeth. Cheliceral measurements (means of 8 specimens); BL: 94.1 ± 1.865 , BH: 36.0 ± 1.210 , CL: 49.8 ± 1.146 , BL/BH: 2.63 ± 0.0525 , BL/CL: 1.88 ± 0.0249 . Palpus of usual shape; tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 9 specimens); femur: 4.94 ± 0.2693 , genu: 8.50 ± 0.2635 , tibia: range 4-5, tarsus: range 8-10.

Scutum: Tectum with about 8 rather small teeth. Sensillary area triangular; basal plate of two widely separated bands; apodeme prominent; bulla triangular; carina thin, long; ridges rather strong, ridges medial to sensillary bases fused with posterior ridge and somewhat prominent at this point (resembling members of the sub-

genus *Eutrombicula*); sensilla flagelliform, flexible, stems thin and finely tapered, with basal branches short and distal branches few, fine, and long. Scutal measurements (means of 11 specimens); ASL: 80.1 ± 2.605 , SB: 37.4 ± 1.171 , TS: 30.4 ± 1.974 , SENS: about 100, ASL/SB: 2.11 ± 0.0489 .

Remarks.—*Trombicula gurneyi* is closely related to *T. kansasensis*, as seen in both larval and nymphal stages. The species may be separated by the larger size and elongated cheliceral base of *T. kansasensis*.

These two species show puzzling similarities to members of the subgenus *Eutrombicula* in the nymphal stage. Both species have the fine flagelliform sensilla with fine branches and the "bilobed" appearance of the posterior scutal ridge, although this latter feature is not so pronounced as in true *Eutrombicula*.

Trombicula gurneyi is rather easily cultured and has been reared through a complete generation in the laboratory. Food of the postlarval stages was collembolan eggs.

Specimens examined.—Total 16 nymphs, as follows: ARKANSAS. *Little River County*: 5 mi. S Ashdown, *Eumeces laticeps*, May 3, 1954 (4 nymphs, reared RBL-DAC). KANSAS. *Barber County*: Aetna, *Dipodomys ordii*, July 11, 1955 (2 nymphs, reared DAC); 2 mi. S Aetna, *Dipodomys ordii*, September 14, 1953 (1 nymph, reared DAC, idet. by larval skin); 4 mi. S Aetna, *Peromyscus maniculatus*, October 7, 1951 (1 nymph, reared LJL). *Douglas County*: Univ. Kansas Natural History Reservation, *Eumeces fasciatus*, June 27, 1952 (2 nymphs, reared DAC), and *Peromyscus maniculatus*, October 20, 1951 (3 nymphs, reared DAC). *Rawlins County*: *Citellus tridecemlineatus*, July 28, 1948 (2 nymphs, reared LJL). NEBRASKA. *Webster County*: 3 mi. E Guide Rock, *Heterodon nasicus*, August 5, 1951 (1 nymph, reared LJL).

Trombicula kansasensis Loomis

(Figs. 56, 77, 114, 115)

Trombicula kansasensis Loomis, 1955, Univ. Kansas Sci. Bull., vol. 37, pp. 260-262 (*larva*).

Description of nymph.—Resembles *T. gurneyi* except as follows: Body: About 0.8 mm. long, color orange. Setae similar to those of *T. gurneyi* but longer; posterior setae about 65 μ long. Sternum with 4 setae (1 specimen). Measurements of tarsus I (1 specimen); TL: 128, TH: 58, TL/TH: 2.2.

Gnathosoma: Cheliceral base elongated, punctate, area of articulation elongated; apodeme of blade strongly constricted; blade with about 18 teeth. Cheliceral measurements (1 specimen); BL: 120, BH: 40, CL: 62, BL/BH: 3.0, BL/CL: 1.9. Palpus large, rather elongated, tarsala about 12 μ long. Setal counts (1 specimen); femur: 6, genu: 10, tibia: 5, tarsus: 9.

Scutum: Measurements (1 specimen); ASL: 104, SB: 40, TS: 46, ASL/SB: 2.6.

Remarks.—The key couplet separating *T. kansasensis* from *T. gurneyi* uses the longer cheliceral base of *kansasensis*. A second character is the length of the posterior body setae; those of *kansasensis* are twice as long as those of *gurneyi*.

Specimens examined.—Total 1 nymph, as follows: KANSAS. Barber County: 4 mi. S Aetna, *Neotoma micropus*, July 11, 1955 (1 nymph, reared DAC, idet. by larval skin).

Trombicula kardosi Loomis

(Figs. 59, 78, 161, 174, 175)

Trombicula kardosi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 929-930 (larva).

Trombicula (Neotrombicula) kardosi, Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1299 (larva).

Description of nymph.—Resembles *T. fitchi* except as follows:

Body: About 0.6 mm. long, color orange. Setae similar to those of *T. fitchi*, but posterior setae with occasional long branches among shorter branches of distal halves; posterior setae about 65 μ long. Measurements of tarsus I (means of 7 specimens); TL: 108 ± 1.091 , TH: 56.1 ± 1.534 , TL/TH: 1.93 ± 0.0565 .

Gnathosoma: Cheliceral blade with about 17 small teeth. Cheliceral measurements (means of 7 specimens); BL: 111.0 ± 0.7228 , BH: 38.6 ± 1.042 , CL: 54.4 ± 0.8401 , BL/BH: 2.89 ± 0.0799 , BL/CL: 2.04 ± 0.0368 . Palpus with tarsala about 11 μ long. Setal counts; femur (5 specimens): 3.3 ± 0.1225 ; genu (6 specimens): 7.83 ± 0.1923 , tibia: range 3-5, tarsus: range 8-9.

Scutum. Generally resembles that of *T. fitchi*; sensilla usually with more numerous branches, resembling those of *T. lipovskiyi*. Scutal measurements (means of 6 specimens); ASL: 94.2 ± 2.057 , SB: 36.8 ± 0.4474 , TS: 27.6 ± 0.2974 , SENS: about 125, ASL/SB: 2.57 ± 0.0761 .

Specimens examined.—Total 7 nymphs, as follows: KANSAS. Douglas County: 4½ mi. W, 3 mi. S Baldwin, *Sciurus niger*, November 28, 1951 (7 nymphs, reared DAC).

Trombicula merrihewi Loomis and Lipovsky

(Figs. 38, 89, 136, 137, 165, 181, 232)

Trombicula merrihewi Loomis and Lipovsky, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 51 (larva).*Description of nymph.*—Resembles *T. crossleyi* except as follows:

Body: About 0.6 mm. long, color not known. Body setae short; branches fine, long, rather sparse; tips of posterior setae of 2 or 3 branches; posterior setae about 14 μ long. Measurements of tarsus I (means of 10 specimens); TL: 69.0 ± 0.6146 , TH: 36.5 ± 0.4281 , TL/TH: 1.89 ± 0.0278 .

Gnathosoma: Cheliceral base punctate; blade with about 14 small teeth. Cheliceral measurements (means of 10 specimens); BL: 76.8 ± 0.827 , BH: 28.2 ± 0.512 , CL: 33.0 ± 0.516 , BL/BH: 2.75 ± 0.0401 , BL/CL: 2.32 ± 0.0359 . Palpus with claw more normal in shape; tibial setae nude or nearly so; tarsus with setae with reduced branching, tarsala about 7 μ long. Setal counts (means of 10 specimens); femur: 3.0 (no variation); genu: 4.75 ± 0.1539 , tibia: range 4-5, tarsus: range 8-9.

Scutum: Tectum with about 8 prominent teeth on margin. Sensillary area triangular in appearance; strong ridges posterior to sensillary bases, others weak; bulla apparently unusually elevated; carina thick; without unusually elongated parascutal setae; sensilla subclavate. Scutal measurements (means of 10 specimens); ASL: 59.1 ± 1.120 , SB: 25.1 ± 0.888 , TS: 19.4 ± 0.612 , SENS: about 60, ASL/SB: 2.38 ± 0.0789 .

Remarks.—This species is readily recognized by the unusually short (14 μ) posterior body setae.

The occurrence of larvae on bats strongly suggests that the nymphs inhabit caves. Of the characters given above, the reduced branching of the palpal setae seems most likely to be a modification for this habitat. Of the species probably dwelling in caves as postlarvae, *Speleocola tadaridae* also has reduced branching of palpal setae, but *Whartonia sensae* and *Euschöngastia pipistrelli* do not. Also, *Trombicula ornata*, a species related to *T. merrihewi*, but not taken from bats, shows a similar reduction in branching.

Specimens examined.—Total 19 nymphs, as follows: OKLAHOMA. Woods County: 6 mi. S, 2 mi. W Aetna, Kans., *Tadarida mexicana*, August 24, 1949 (19 nymphs, reared LJL).

Trombicula montanensis Brennan

(Figs. 9, 12, 54, 73, 122, 123, 167, 239)

Trombicula montanensis Brennan, 1946, Jour. Parasit., vol. 32, pp. 441-442 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1306-1310 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, rounded, color yellow to orange. Setae with thick stems, rather short; branches fine, numerous; posterior setae with tips somewhat rounded, with several tiny branches; posterior setae about 30 μ long. Sternal area variable; usually closed behind but rarely open; usually about pentagonal in shape but rarely elongated-rectangular; with about 8 setae. Measurements of tarsus I (means of 17 specimens); TL: 89.9 ± 1.6997 , TH: 45.1 ± 0.8613 , TL/TH: 1.99 ± 0.0251 .

Gnathosoma: Cheliceral base of usual shape, punctate; blade normal, with about 13 teeth of intermediate size. Cheliceral measurements (means of 9 specimens); BL: 90.8 ± 1.9985 , BH: 33.6 ± 0.7094 , CL: 46.2 ± 0.8127 , BL/BH: 2.71 ± 0.0611 , BL/CL: 1.96 ± 0.0176 . Palpus of usual shape; dorsal genual setae often nude; claw and accessory claws rather small; dorsal tibial setae occasionally nude; tarsus with tarsala about 9 μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 9 specimens); femur: 4.00 ± 0.2079 , genu: 8.28 ± 0.1900 , tibia: range 4-5, tarsus: 9.

Scutum: Tectal margin with about 10 teeth. Sensillary area triangular in appearance; basal plate rather simple, of two halves; apodeme well developed; bulla triangular, prominent, conspicuously domelike; carina thick, only slightly elevated, often difficult to distinguish from bulla; posterior ridge weak, ridges medial to sensillary bases weak, others strong; sensilla with short branches basally but longer ones distributed over rest of stems, stems flexible, flagelliform or slightly thickened. Scutal measurements (means of 16 specimens); ASL: 71.8 ± 0.9593 , SB: 32.4 ± 0.7161 , TS: 22.7 ± 0.506 , SENS: about 80, ASL/SB: 2.26 ± 0.0418 .

Remarks.—*Trombicula montanensis* is a common chigger of the central states region. The best recognition character for nymphs seems to be the four apical nude setae of the palpal tarsus; other species of *Trombicula* (*Trombicula*) have either three, five, or six such setae.

Nymphs of *T. montanensis* show considerable variation in morphology. The shape of the sternal area, which is relatively constant for other species, is dimorphic in *montanensis*; occasional specimens from Barber County, Kansas, possess an elongated-rectangular sternum which is open behind, instead of the usual closed pentagonal sternum. Other variation is noticeable in the scutal area. A carina is plainly visible on some specimens but is not visible on other equally well-mounted specimens. A dimorphic condition of the sensilla occurs also; the two distinct forms are a flagelliform stem resembling that of *T. gurneyi* and a slightly thickened stem resembling that of *T. lipovskyi*. The more common type is the latter one, but occasional specimens from Barber County, Kansas, and Webster County, Nebraska, have flagelliform sensilla. The flagelliform type is more prevalent in a series of 68 nymphs from Barber County collected in August of 1948, but is uncommon on specimens taken in 1949, 1952, and 1953 in Barber County. Associated larvae show no unusual variation.

The reasons behind these unusual variations are not known. The specimens at hand are not sufficient to indicate whether genetic or environmental forces produce these effects.

Nymphs and adults of *T. montanensis* feed readily upon collembolan eggs. This species has been reared through a complete generation.

Specimens examined.—Total 108 nymphs, as follows: KANSAS. Barber County: 5 mi. E Aetna, *Perognathus hispidus*, July 26, 1952 (4 nymphs, reared DAC, 1 idet. by larval skin); 4½ mi. S, 1 mi. W Aetna, *Citellus tridecemlineatus*, September 16, 1953 (2 nymphs, reared DAC) and *Cynomys ludovicianus*, September 16, 1953 (1 nymph, reared DAC); 4 mi. S Aetna, *Neotoma micropus*, August 22, 1948 (68 nymphs, reared LJL); 10½ mi. W Hardtner, *Cynomys ludovicianus*, August 21, 1949 (5 nymphs, reared LJL), and July 26, 1952 (7 nymphs, reared DAC); 3½ mi. W Hardtner, *Cynomys ludovicianus*, August 23, 1949 (1 nymph, reared LJL). Rawlins County: 11 mi. S McDonald, *Cynomys ludovicianus*, July 27, 1948 (1 nymph, reared LJL). Seward County: 4 mi. NE Liberal, *Masticophis flagellum*, September 12, 1948 (1 nymph, reared LJL). NEBRASKA. Hitchcock County: 4 mi. E Stratton, *Cynomys ludovicianus*, August 8, 1949 (1 nymph, reared LJL); 13 mi. S Trenton, *Citellus tridecemlineatus*, August 8, 1949 (9 nymphs, reared LJL).

Webster County: 3 mi. E Guide Rock, *Heterodon nasicus*, August 5, 1951 (7 nymphs, reared DAC). OKLAHOMA. *Woods County*: 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinos*, October 7, 1951 (1 nymph, reared DAC).

Trombicula ornata Loomis and Lipovsky

(Figs. 58, 162, 202)

Trombicula ornata Loomis and Lipovsky, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 47 (larva).

Description of nymph.—Resembles *T. crossleyi* except as follows:

Body: About 0.7 mm. long, rather rounded, color not known. Posterior setae about 25 μ long. Sternal area larger than that of *T. crossleyi*, with about 4 to 6 setae. Measurements of tarsus I (means of 7 specimens); TL: 90.1 ± 2.176 , TH: 38.7 ± 0.6801 , TL/TH: 2.34 ± 0.0812 .

Gnathosoma: Cheliceral base unusually elongated, area of articulation elongated; blade rather stout but shearlike, with about 17 small teeth. Cheliceral measurements (means of 7 specimens); BL: 111.3 ± 1.229 , BH: 30.7 ± 0.5217 , CL: 39.4 ± 0.7189 , BL/BH: 3.63 ± 0.1286 , BL/CL: 2.83 ± 0.0474 . Palpus with claw more normal in size; accessory claw thin; tibial setae nude or nearly so; tarsala about 9 μ long. Setal counts (6 specimens); femur: 3.00 (no variation); genu: 4.79 ± 0.4062 , tibia: range 4-5, tarsus: 9.

Scutum: Sensillary area markedly triangular in shape; strong ridges anterior to and posterior to sensillary bases, others weak; sensillary bases not unusually prominent. Scutal measurements (means of 6 specimens); ASL: 72.2 ± 0.9700 , SB: 28.9 ± 0.5084 , TS: 24.7 ± 0.7603 , SENS: about 75, ASL/SB: 2.48 ± 0.0538 .

Remarks.—This species appears most similar to *Trombicula merrihewi*, although similarities are more obvious in the larval stage than in the nymphal stage. *Trombicula ornata* resembles the larger *Trombicula* species almost as much as it resembles *T. crossleyi* and relatives, but the affinities of *ornata*, through *merrihewi*, would seem to be with *crossleyi* and *trisetica*.

Trombicula ornata is easily separated from these species by the elongated cheliceral base which it possesses.

Specimens examined.—Total 18 nymphs, as follows: KANSAS. *Barber County*: 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (16 nymphs, reared LJL); 4 mi. S Aetna, *Neotoma micropus*, August 22, 1949 (2 nymphs, reared LJL).

Trombicula trisetica Loomis and Crossley

(Figs. 1-7, 198)

Trombicula trisetica Loomis and Crossley, 1953, Jour. Kansas Ent. Soc., vol. 26, p. 32 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1321-1323 (*larva*).

Description of nymph.—Resembles *T. crossleyi* except as follows:

Body: About 0.6 mm. long. Posterior setae about 25 μ long. Measurements of tarsus I (means of 10 specimens); TL: 82.8 \pm 1.397, TH: 40.1 \pm 0.647, TL/TH: 2.09 \pm 0.0277.

Gnathosoma: Cheliceral base punctate; blade with about 17 small teeth. Cheliceral measurements (means of 10 specimens); BL: 90.5 \pm 1.046, BH: 30.4 \pm 0.3711, CL: 40.5 \pm 0.2687, BL/BH: 2.91 \pm 0.0407, BL/CL: 2.19 \pm 0.0278. Palpus with tarsala about 9 μ long. Setal counts (means of 10 specimens); femur: 2.95 \pm 0.0049, genu: 3.00 (no variation); tibia: range 5-6, tarsus: 9.

Scutum: Sensilla less expanded than those of *T. crossleyi*, distal branches somewhat longer. Scutal measurements (means of 10 specimens); ASL: 66.1 \pm 1.059, SB: 30.3 \pm 0.7753, TS: 22.8 \pm 0.4163, SENS: about 85, ASL/SB: 2.21 \pm 0.0722.

Specimens examined.—Total 18 nymphs, as follows: KANSAS. *Douglas County*: Univ. Kansas Natural History Reservation, *Elaphe obsoleta*, September 10, 1952 (18 nymphs, reared DAC).

Genus *Walchia* Ewing

Walchia Ewing, 1931, Proc. U. S. Nat. Mus., vol. 80, p. 10, [type *Trombidium glabrum* Walch (not *Trombidium glabrum* Dugès) = *Walchia pinque* Gater] (*larva*); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 91 (*postlarvae*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 161 (*adult*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1362 (*larva*). *Gahrlepiea* (*Walchia*), Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 393 (*nymph*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates of coxae I absent. (3) Body setae branched, not expanded, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) *Tarsus I* with dorsoapical stump-like process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome* short, blunt; with about twenty short apical nude or nearly nude setae. (9) *Pharynx* marked with a reticulate pattern. (10) Tectum almost square, hyaline, margin with teeth; without tectal seta. (11) *Sensillary area* wide; mean ratio ASL/SB: 1.3. (12) Without branched body seta in sensillary area. (13) Sensilla straight, with branches.

Additional features (nymph).—(14) Body small (about 0.5 mm. long). (15) Sternum elongated-rectangular in shape, closed behind. (16) Tarsus I elongated. (17) *Articulating area of cheliceral base on posterior margin; posterior tip of cheliceral base elevated.* (18) Palpus stout, small; claw slightly elongated, rather straight; distal portion of tibia not unusually elongated; two accessory claws; tarsus with seven to nine branched setae and *one apical nude seta.* (19) Hypostome with about ten ventral branched setae. (20) Basis capituli of normal shape. (21) Crista a short narrow rod. (22) Sensillary area with basal plate of two well-separated halves; bulla rather large; carina absent; sensillary bases placed well lateral; anterior and posterior ridges present; lateral ridges present but less prominent than ridges medial to sensillary bases; apodeme small. (23) *Only two parascutal setae.*

Remarks.—One species of the genus, *Walchia americana*, is known from the United States. Ten or more species are known from the Asiatic-Pacific Region. Nymphs of four of these species have been described by Womersley (1952:285).

Womersley (1952:278) considered *Walchia*, *Schöngastiella* Hirst, and *Gateria* Ewing to be subgenera of *Gahrlipeia* Oudemans. This opinion was based upon comparisons of both larvae and nymphs of members of these genera. Womersley's opinion may certainly be correct; the features mentioned in his descriptions of nymphs do not appear to indicate generic separation for these forms. I am persisting, however, in using the generic name *Walchia* (as did Loomis, 1956), at least until Womersley's more conservative approach can be substantiated.

While Womersley's descriptions are not adequate for close comparisons, it does appear that at least some of the species he describes will not key out to *Walchia* in my key. In the generic diagnoses for *Gahrlipeia*, Womersley states that one epistomal seta (tectal seta) is present. However, this seta was clearly seen by him on only two of ten species, and was but indistinctly seen on two others. The tectal seta is definitely absent on both nymphs and adults of *Walchia americana*, and I have included this as a generic feature and used it in the key to genera, to separate *Walchia* from *Schoutedenichia*. If Womersley's descriptions are correct some additional feature must be found. The single pair of parascutal setae or the single apical nude seta of the palpal tarsus of *Walchia* possibly separate these two genera; unfortunately these features are not mentioned by Womersley.

Walchia americana Ewing

(Figs. 35, 84, 118, 119, 147, 188, 203, 235)

Walchia americana Ewing, 1942, Jour. Parasit., vol. 28, p. 491 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1363-1365 (*larva*).

Description of nymph.—Body: About 0.5 mm. long, rounded, color white. Setae short, stems thick at bases and abruptly tapered, with many short branches; posterior setae with tips of 2-3 tiny branches; posterior setae about 14 μ long. Sternum closed behind, elongated posteriorly, often with an indication of incipient longitudinal division; with about 8 setae. Tarsus I with small stumplike process projecting from apical dorsal margin. Measurements of tarsus I (means of 7 specimens); TL: 77.9 ± 1.945 , TH: 46.7 ± 1.646 , TL/TH: 1.67 ± 0.0606 .

Gnathosoma: Cheliceral base of characteristic shape, punctate; blade shearlike, with about 10 small teeth. Cheliceral measurements (means of 10 specimens); BL: 56.3 ± 0.731 , BH: 28.0 ± 0.4899 , CL: 28.0 ± 0.648 , BL/BH: 2.01 ± 0.0434 , BL/CL: 2.01 ± 0.0456 . Palpus with accessory claws long; tarsus with tarsala about 9 μ long, apical nude seta on inner surface. Setal counts (means of 10 specimens); femur: 4.95 ± 0.0879 , genu: 7.4 ± 0.2082 , tibia: range 3-4, tarsus: range 7-9.

Scutum: Sensillary area broadly transverse-oval; apodeme reduced; major posterior ridge running medial to sensillary bases; ridges anterior and posterior to sensillary bases weak; posterior ridge discontinuous, ends joined by small secondary ridge; bulla triangular, prominent; carina absent; sensilla with stems thickened but flexible, with short basal branches and longer branches on remainder of stems. Scutal measurements (means of 10 specimens); ASL: 45.1 ± 0.836 , SB: 34.6 ± 0.7023 , SENS: about 75, ASL/SB: 1.32 ± 0.0326 .

Remarks.—In Womersley's (1952:280) key to species of *Gahrleipia*, *Walchia americana* will key out to *G. rustica*, from which it may be separated by the shorter posterior body setae (14 μ long in *americana*, 32 μ long in *rustica*).

Walchia americana was reared on four occasions and reached a complete generation on three of these occasions. The nymphs and adults were fed upon active stages of the collembolan, *Sinella curviseta*.

Specimens examined.—Total 21 nymphs, as follows: KANSAS. Douglas County: *Sciurus niger*, January 19, 1950 (2 nymphs, reared LJJL); 2 mi. S Warden, *Sciurus niger*, November 28, 1949 (1 nymph,

reared LJL); 4½ mi. W, 3 mi. S Baldwin, *Sciurus niger*, November 28, 1951 (4 nymphs, reared DAC). *Jefferson County*: 10 mi. W Midland, November 14, 1953 (14 nymphs, reared RBL-DAC).

Additional Genera Known As Postlarvae

This section includes those genera which are known as postlarvae but for which no specimens were available for study. Most are included in the key to genera on characters given in descriptions by other authors. Many of these descriptions are brief; often they contain no indication of characters considered as generic in the present paper. Thus it is not possible to give full diagnoses for these genera. In the discussions, further features are indicated, usually by comparisons with better known genera.

SUBFAMILY TROMBICULINAE EWING

Genus *Ascoschöngastia* Ewing

Ascoschöngastia Ewing, 1946, Proc. Biol. Soc. Washington, vol. 59, p. 71 (type *Neoschöngastia malayensis* Gater) (*larva*).
Schöngastia (*Ascoschöngastia*), Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 384 (part.) (*nymph*).

Diagnostic features (nymph).—Apparently identical with *Euschöngastia*.

Remarks.—This genus is recognized by Wharton and Fuller (1952:71) for trombiculine species which as larvae have expanded sensilla and the PL setae off of the scutum. Five species are included. Womersley (1952:384) described the nymph of *A. malayensis* and concluded that it was not generically separable from those of species which he placed in *Schöngastia* (*Ascoschöngastia*) (= *Euschöngastia*). Womersley confirms in a footnote (*ibid*, p. 170) that *Euschöngastia* has priority over *Ascoschöngastia* and that this synonymy should obtain in his system.

The description of the nymph of *A. malayensis* as given by Womersley is not adequate for purposes of comparison. Therefore, I must follow Womersley in regarding *malayensis* as inseparable from nymphs of *Euschöngastia*.

Genus *Doloisia* Oudemans

Doloisia Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 87 (type *Doloisia synoti* Oudemans) (*larva*); Sasa, 1953, Japanese Jour. Exp. Med., vol. 23, p. 427 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 157 (*nymph*).

Diagnostic features (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (8) Hypostome pointed, projecting, with about eight apical nude setae. (10) Tectum with teeth on margin. (11) Sensillary area broad, ratio ASL/SB: 0.7-1.2

Remarks.—The nymph of *Dolosisia okabei* Sasa *et al.*, has been well described by Sasa (1953:427); the nymph of *D. oculicola* (Womersley) has been described by Womersley (1952:383); also, Audy (1954:157) has given some nymphal characters. The above diagnosis is based upon these publications. From Sasa's figures it appears that the palpal shape and the apical nude setae of the hypostome may be distinctive, as well.

Larvae of *Dolosisia* have small characteristic scuta with expanded sensilla.

The general facies of nymphs as presented by authors is distinctive; the scutum of the nymph is somewhat similar to that of *Guntherana* but the species are abundantly distinct from that genus.

Genus *Gahrlipeia* Oudemans

Typhlothrombium Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 105 (type *Typhlothrombium nanus* Oudemans) (*larva*) (not *Typhlothrombium* Berlese).

Gahrlipeia Oudemans, 1912, Ent. Ber. Amst., vol. 3, p. 273 (type *Typhlothrombium nanus* Oudemans) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 393 (*nymph*).

Gateria Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 295 (type *Gahrlipeia fletcheri* Gater) (*larva*).

Schöngastiella Hirst, 1915, Bull. Ent. Res., vol. 6, p. 188 (type *Schöngastiella bengalensis* Hirst) (*larva*).

Diagnostic features (nymph).—Same as those for *Walchia*.

Remarks.—Womersley (1952:279) synonymized the genera *Gateria*, *Schöngastiella*, and *Walchia* with *Gahrlipeia*, on both larval and postlarval evidence. Some authors have been somewhat reluctant to accept this synonymy (see Audy 1954:161). Womersley described nymphs for species in all four genera, and on the basis of his descriptions, they are only specifically separable. I have used the generic name *Walchia* for *W. americana* and based my diagnosis of the nymph on that species. It is difficult to say how closely Womersley's species fit that diagnosis (see discussion of *Walchia*). Thus it is impossible for me to evaluate the *Gahrlipeia* complex. Quite possibly Womersley's solution is the correct one.

Genus *Guntherana* Womersley and Heaslip

Guntherana Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 132 (type *Neoschöngastia kallipygos* Gunther) (*larva*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 83 (*larva, postlarva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 372 (*postlarva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 156 (*larva, postlarva*).

Diagnostic features (nymph).—(2) Precoxal plates of coxae I present but not fused in midline to form longitudinally divided

sternum. (3) Body setae branched; adjacent setae of similar lengths. (11) Sensillary area wide, ratio ASL/SB: about 1.1.

Remarks.—These features are taken from Womersley (1952:372) and Audy (1954:156). Presumably they hold for the nymph and adult of *G. kallipygos*, and for *G. tindalei* and *G. translucens*, the latter known only as adults. Larvae of *Guntherana* are distinguished by the presence of caudal plates.

Relationships of the genus *Guntherana* are hard to define on the basis of the brief published descriptions. Nymphs appear to resemble those of *Trombicula*; however, the presence of precoxal plates indicates similarity with *Neoschöngastia* and the scutum resembles that of members of the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera. A detailed study of nymphs of the genus *Guntherana* would be of the greatest interest.

Genus *Heaslipia* Ewing

Trombiculoides Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 101 (type *Trombiculoides gateri* Womersley and Heaslip) (*larva*) (not *Trombiculoides* Jacot).

Heaslipia Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 103 (type *Trombiculoides gateri* Womersley and Heaslip) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 422 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 149 (*nymph*).

Diagnostic features (nymph).—(10) Tectum large, an elongate triangular cone, not hyaline, margin without teeth or serrations. Otherwise similar to *Euschöngastia*.

Remarks.—This diagnosis is after Womersley (1952:422) and Audy (1954:149) based upon *Heaslipia gateri*. Quite possibly the conelike tectum will not distinguish nymphs of *Heaslipia* from nymphs of some *Euschöngastia*. Larvae are similar to those of *Trombicula* but have additional scutal setae. The genus is monotypic.

Genus *Ipotrombicula* Womersley

Ipotrombicula Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 323 (type *Trombicula elegans* Womersley) (*adult only*).

Diagnostic feature (adult).—(12) With branched body seta in sensillary area.

Remarks.—This genus is monotypic for *I. elegans*, known only as adult. Except for the key character of the possession of a branched seta in the sensillary area, this species would probably be placed in *Trombicula*, subgenus *Eutrombicula*; it possesses eyes in typical *Eutrombicula* position. Indeed this may be its proper place.

Genus *Schöngastia* Oudemans

Schöngastia Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 87 (type *Thrombidium vandersandei* Oudemans) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 376 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 150 (*nymph*).

Diagnostic features (nymph).—(2) Precoxal plates of coxae I present but not fused in midline to form longitudinally divided sternum. (3) Adjacent body setae of similar lengths. (11) Sensillary area triangular; ratio ASL/SB: about 2.0.

Remarks.—Nymphs of three species of *Schöngastia* were described by Womersley (1952:381-387). Womersley does not mention the precoxal plates, but Audy (1954:150) says that these are present. The nymphs, as described by Womersley, show no other features clearly separating them from *Trombicula*.

Genus *Schoutedenichia* Jadin and Vercammen-Grandjean

Schoutedenichia Jadin and Vercammen-Grandjean, 1954, Ann. Mus. Congo Tervuren, Zool., vol. 1, p. 195 (type *Schoutedenichia fulleri* Jadin and Vercammen-Grandjean) (*larva*).

Diagnostic features (nymph).—(2) Precoxal plates of coxae I absent. (5) Tarsus I with dorsoapical stumplike process. (10) Tectum with a single tectal seta.

Remarks.—These features are taken from descriptions by Jadin and Vercammen-Grandjean (1954:287, 289) of nymphs of *S. penetrans* and *S. pirloti*. In combination these features separate nymphs of *Schoutedenichia* from those of other genera. From the illustrations by Jadin and Vercammen-Grandjean it may be seen that the genus has some features of the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera, including the scutal shape, the blunt hypostome with about twenty short apical setae, and the features of palpal setation. As previously noted, *Schoutedenichia* is very probably closely related to this group of genera.

Genus *Speotrombicula* Ewing

Speotrombicula Ewing, 1946, Jour. Parasit., vol. 32, p. 437 (type *Trombicula trifurca* Ewing) (*adult only*); Wharton and Fuller, Mem. Ent. Soc. Washington, no. 4, p. 90 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 324 (*adult*).

Diagnostic feature (adult).—(4) Claws on tarsus I trifurcate distally.

Remarks.—*Speotrombicula* is monotypic for *S. trifurca*, known only as adult. Judging from Ewing's (1933:3) description the species is a *Trombicula* except for the key character of the divided claws. However, this description is brief.

Genus *Walchiella* Fuller

Walchiella Fuller in Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 95 (type *Trombicula oudemansi* Walch) (*larva*).

Diagnostic features (nymph).—None.

Remarks.—Womersley (1952:380) has described the nymph of *Walchiella oudemansi*, which he included in *Schöngastia* (*Schöngastia*). His description indicates no features which separate the nymph from those of *Trombicula*. A possible useful character is present in the posterior body setae, which have a subterminal branch that is unusually long (as long as the seta itself). Considering the variation in form of the posterior body setae, as observed in *Euschöngastia* and *Trombicula*, this character does not seem to have generic significance.

Walchiella is monotypic for *W. oudemansi*. Larvae have six segments in legs II and III, expanded sensilla, and five scutal setae.

COMPARISON OF SYSTEMS OF CLASSIFICATION

Workers are in general agreement concerning the classification based primarily on larvae. In the main similar generic levels are given in recent papers, but there is less agreement on generic alignment in subfamilies. Audy (1954:134-135) presents in tabular form his own generic arrangement, that of Wharton and Fuller (1952), and that of Womersley (1952). Although these systems are divergent it may be seen that there is general agreement as to the status of most of the genera.

These systems of classification are based primarily on the larval stage but taxonomic characters of known postlarvae were quite evidently considered. The classification in the present paper is based upon both larval and postlarval stages, perhaps with the latter stages given more than the usual weight.

Concerning the species level, there appears to be no reason for insisting that species be distinct from one another in both larval and postlarval stages. The majority of the species studied are distinct in both stages, although some (for example, species of *Pseudoschöngastia*) are more readily separated as larvae while others (species of *Neoschöngastia*) are more readily separated as nymphs. An area of greater interest in the comparison of systems is at the more arbitrary generic and higher levels, where weighting of characters becomes important.

With the two classifications there are four types of generic categories as regards distinctiveness; these are (1) genera distinct, *i. e.*,

recognizable by a character or combination of characters, in both the larval and postlarval stages, (2) genera distinct in the larval stage but not recognizable in postlarval stages, (3) genera distinct in postlarval stages but not recognizable in the larval stage, and (4) genera distinct in neither stage but recognizable by some other criterion. Examples of the first three of these points are known. These considerations, of course, apply to subgenera, subfamilies, and other supraspecific categories as well as to genera.

Most of the subgenera and genera were found to be recognizable on morphological characters of both larval and postlarval stages. Members of the subgenus *Neotrombicula* are recognizable on larval characters but no postlarval characters were found for this group. Species in the genus *Blankaartia* and perhaps the subgenus *Leptotrombidium* are difficult to recognize as larvae but are readily recognized on postlarval characters. The genus *Euschöngastoides*, as recognized in the present paper, contains two species clearly distinct as nymphs but as larvae they are members of different genera. With these few exceptions, evidence of the nymphal stage corroborates the classification based on larvae.

Of the exceptions noted above, *Blankaartia* and *Neotrombicula* are not serious discrepancies; in both cases relationships are clear in larval and postlarval stages. In other genera, also, the degree of distinctiveness is not the same in the two phases of the life history. Some as yet undetected character may serve to separate nymphs of species of *Neotrombicula* from those of the typical subgenus. Further studies of the larvae of *Blankaartia* may make the identification of larvae of that genus easier. In these cases evidence from postlarval stages does not show that relationships are other than those indicated in the larval stage; the matter is one of relative distinctiveness.

A question posed by these exceptional cases concerns the status of genera and subgenera; namely, should a genus (or subgenus) necessarily be recognizable in both larval and postlarval stages in order to be acceptable? Womersley, in a revision of trombiculids, considered postlarval evidence and concluded (1952:9), "Such a revision shows that many of the larval genera which have been proposed cannot be separated in the nymphal or adult stages, should not be used except perhaps for convenience, as subgenera based on larval features only." Audy, in consideration of this problem writes (1954:127), ". . . rigid ideas on the employment of either larval or adult characteristics are to be deplored." "Certainly,

species and subgenera based entirely on morphological larval characters may be fully acceptable though the free extension of this to genera (and even to subfamilies, as has been done) is debatable in particular instances." The present writer is more in agreement with Audy than with Womersley. It does not seem possible to draw a hard and fast rule for cases of relative distinctiveness. The creation of genera indistinguishable in one phase of the life history poses practical problems rather than philosophical ones.

The genus *Euschöngastoides* poses a more difficult problem. As explained in the taxonomic section of this paper, the two species of *Euschöngastoides*, as larvae, key out to different genera, *Trombicula* and *Euschöngastia*. Except for the key character, the nature of the sensillum, the two larvae are very similar. As nymphs, the two species are similar to each other but differ markedly from *Trombicula* and *Euschöngastia*. The relationships of the two species (on nymphal evidence) appear to be with *Pseudoschöngastia* and *Walchia*. If the relationships as indicated by the nymphs are correct, then the erroneous placement of the larvae was due to the rigid use of a single key character in separating *Trombicula* and *Euschöngastia*. If the relationships are correct on larval evidence, the similarity of the nymphs (and of other larval characters) must be assumed to be due to parallelism. The writer feels that the nymphal evidence is the more convincing and thus gives generic status to *Euschöngastoides*.

Undoubtedly other similar cases will arise. If these are judged on their individual merits, without undue weighting of characters of any stage, the result should be a more natural system of classification. The postlarval evidence should be considered as additional knowledge concerning the relationships of the organisms.

The remaining genera are distinct as such in both phases of the life history. Both *Euschöngastia* and *Speleocola* seem closely related to *Trombicula* in both stages. In *Cheladonta* and *Neoschöngastia*, the larvae are similar to those of *Euschöngastia*, but postlarvae of these two genera are quite distinctive. *Pseudoschöngastia* and *Walchia* are similar to one another as nymphs, more so than as larvae.

RUDIMENTS OF PHYLOGENY

As previously stated, this study is restricted mainly to species in North America, and the available nymphs represent but a fraction of the species known from this continent. Some genera are known only as larvae. Under these conditions it would not be realistic to attempt to construct a detailed phylogeny of the group. However,

it seems possible that an outline of the evolutionary development of the group might be proposed, since at least the major genera of trombiculids are known as nymphs. The following ideas, therefore, are offered as the writer's opinions; the evidence for them is meager in most cases and further work will undoubtedly indicate modifications. The genera not studied by the writer are not included in this discussion; to do so would be compounding speculation.

The origin of trombiculids is almost certainly in the family Trombidiidae. The distinction between the two families is not clear-cut. Certain genera, such as *Ncotrombidium*, could be placed in either family on morphological grounds (Borland, 1956:30). From evidence available at present, it appears that trombiculids are closely related to members of the trombidiid subfamily Microtrombidiinae, which itself is heterogeneous. Trombiculids are not far removed from the primitive trombidiids (*Johnstoniana* and relatives).

By analogy with the trombidiids, certain characters of some trombiculid nymphs are deduced to be primitive. The primitive condition of the gnathosoma appears to be as follows: Hypostome pointed, projecting, with about eight apical nude setae. Cheliceral base elongated, with posterior tip depressed; cheliceral blade shear-like, with teeth. Palpus large, with numerous setae, with claw and two accessory claws, and tarsus with several apical nude setae. Primitive features of the scutum include: Tectum rounded, margin smooth; with two tectal setae. Crista rodlike, long. Sensillary area simple, circular or oval shaped, with few or no ridges; sensilla without branches; posterior apodeme rodlike. Other primitive characters appear to be the presence of eyes anterior to the sensillary area, the absence of a closed sternum, and a simple circular anus. While unmodified body setae are possibly primitive, so many genera in the family Trombidiidae have highly modified body setae that it seems unsafe to make this generalization for trombiculids. The strongly constricted body of most trombiculid nymphs is seemingly specialized, but again body shapes vary within the family Trombidiidae and there is little to suggest what shape is primitive for the trombiculids.

The specialized conditions for these characters are the alternative ones given in the section on morphology. To repeat them here seems unnecessary. Many of the specialized states are mentioned in the following discussion.

It is more difficult to suggest primitive characters for the larval stage. Few trombidiid larvae are known; most of the described forms belong to the more highly developed trombidiids. The

gnathosomal elements are particularly difficult, since both the cheliceral blade and the palpus seem specialized in larvae of both families. For the scutum a rectangular shape, an anteromedian projection, two anteromedian setae, unexpanded sensilla, and four marginal setae seem primitive. Possibly, undivided femora of the legs is a primitive character but this conclusion is based entirely on comparisons within the family.

To return to the nymphal characters, it is possible to follow in a general way some features of the evolutionary development of two structural areas, the gnathosoma and the scutum. The characters listed above as primitive are found among the genera of the subfamily Leeuwenhoekinae. Although there is some deviation in hypostomal shape, shape of cheliceral elements, and presence of eyes, the general facies for these areas in the Leeuwenhoekinae is primitive. The gnathosomal elements show some modifications in most genera of Trombiculinae. Except for reduced palpal setation and slight cheliceral modification in some species, the genera *Euschöngastia*, *Speleocola*, and *Trombicula* have a primitive condition of gnathosomal elements. *Blankaartia* differs only in the possession of additional accessory claws on the palpus in some species, a situation common in the trombidiiids. Greater modification is seen in *Neoschöngastia*, where palpal claws are elongated, chelicerae shortened, and hypostome blunt; *Cheladonta* has all gnathosomal elements elongated. Finally, the genera *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia* have distinctive chelicerae and markedly modified hypostoma.

Scutal elements are also modified in the subfamily Trombiculinae. These are discussed in detail in the section on morphology. Most noticeable specializations are the reduction in number of tectal setae, shortening and thickening (in some) of the crista, development of ridges and other structures in the sensillary area, modification or reduction of the posterior apodeme, and modification of the sensilla. The genus *Blankaartia*, aside from the possession of a single tectal seta and slight development of the sensillary area, has an essentially primitive scutum. Development of the sensillary area seems to proceed along two different lines among the remaining genera. The sensillary areas of the genera *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia* are quite broadened. The remaining genera have less broadened but seemingly more complicated sensillary areas; those of *Cheladonta* and *Neoschöngastia* each have distinctive features not shared by *Euschöngastia*, *Trombicula*, and *Speleocola*.

From these considerations it is possible to divide the genera into three levels of increasing specialization. The first level, the more primitive state, includes genera of the subfamily Leeuwenhoekinae. The second level, an intermediate state, includes the genera *Blankaartia*, *Euschöngastia*, *Speleocola*, and *Trombicula*. The third level, the most specialized state, includes the genera *Cheladonta*, *Neoschöngastia*, *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia*. It seems likely that these levels represent an evolutionary sequence.

Unfortunately it is not possible to consider more detailed relationships within the Leeuwenhoekinae. Among the five genera only eight species are known as nymphs and these appear to be but slightly modified. Speculation as to their relationships would be fruitless. Possibly, also, the habit of parasitism on vertebrates has arisen more than once and a realistic evaluation must consider the very similar forms in the Trombidiidae.

Blankaartia is the least modified of the intermediate genera and might be considered halfway between the primitive forms and the other intermediate ones. The other intermediate genera, *Trombicula*, *Euschöngastia*, and *Speleocola* appear closely related. The genera *Euschöngastoides*, *Pseudoschöngastia* and *Walchia* are similar and quite possibly represent a valid unit. While they are unhesitatingly considered specialized, it is difficult to avoid the impression that in these genera the sensillary area of the scutum is less modified than is that of the genera of the intermediate level. It might be more reasonable to suggest that these three genera are separately derived from the primitive forms, or at least that they are an early branch from the intermediate group of genera. The other specialized genera, *Cheladonta* and *Neoschöngastia* seem distinctive.

Features of the larval stage essentially confirm this general sequence. The subfamily Leeuwenhoekinae again clearly represents the primitive state. A close relationship between larvae of genera of the intermediate state appears. The specialized genera *Cheladonta*, *Neoschöngastia*, *Euschöngastoides*, and perhaps *Pseudoschöngastia* seem related to the intermediate genus *Euschöngastia* in features of scutal shape and nature of the sensilla. It has been previously noted, however, that the character of the sensilla (expanded vs. flagelliform) which separates the genera *Euschöngastia* and *Trombicula* has led to strange relationships.

While larva and postlarva are adapted to different sorts of existence, the divergence in form is not extreme when compared to other animals with divergent phases of the life history (the holometabolous insects, for instance). Although obviously modified,

the scutal and gnathosomal elements likely perform identical or similar functions in the two stages. In these mites a possible evolutionary mechanism is the transfer of a structural modification from one stage to another stage. The sensillum of the larva of *Euschöngastoides hoplai* seems identical with the sensillum of the nymph of that species; it is possible that in this case the larva has acquired the sensillum of the nymph, since other similar larvae have expanded sensilla. Sensilla may serve different purposes in the two phases of the life history but it is possible that adaptive modifications in the nymph could be of advantage to the larva. No evidence of other such transfers was noted. It is possible, however, that the transfer of such preformed structures from one stage to another differently adapted one could play an important role in the evolution of these mites.

As more postlarvae are described these suggestions as to phylogeny will doubtless require modification. A productive study would be the ecology and functional physiology of these mites, to provide an indication of the specific uses of the structures here considered and thus a better understanding of the selective forces producing them.

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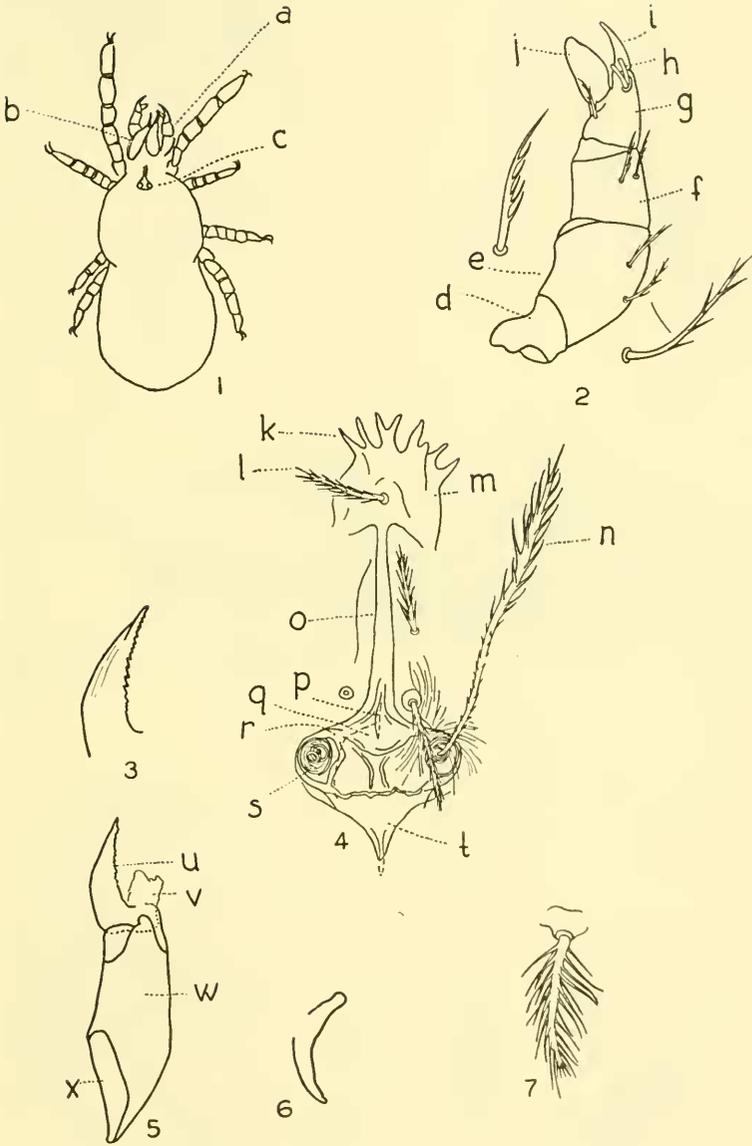
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EXPLANATION OF FIGURES 1-7

Trombicula trisetica, nymph

- Fig. 1. Body shape, dorsal view.
 Fig. 2. Palpus, medial view.
 Fig. 3. Cheliceral blade, lateral view.
 Fig. 4. Scutum, dorsal view.
 Fig. 5. Chelicera, lateral view.
 Fig. 6. Cheliceral apodeme, lateral view.
 Fig. 7. Posterior dorsal body seta.
- | | |
|---------------------------|--|
| a. palpus | n. sensillum |
| b. chelicera | o. crista |
| c. scutum | p. carina |
| d. trochanter | q. bulla |
| e. femur | r. basal plate |
| f. genu | s. sensillary base |
| g. tibia | t. posterior apodeme |
| h. accessory claws | u. cheliceral blade |
| i. claw | v. pseudochela |
| j. tarsus | w. cheliceral base |
| k. teeth of tectal margin | x. area of articulation of cheliceral base with basis capituli |
| l. tectal seta | |
| m. tectum | |

FIGURES 1-7

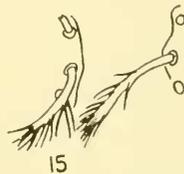
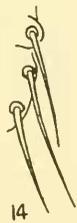
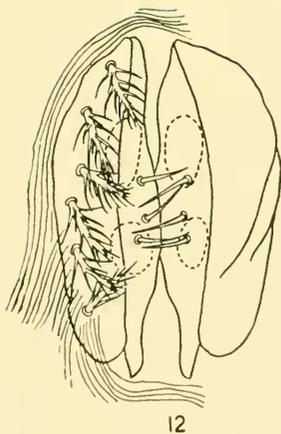
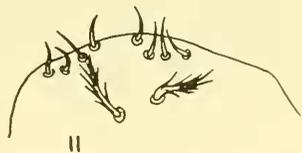
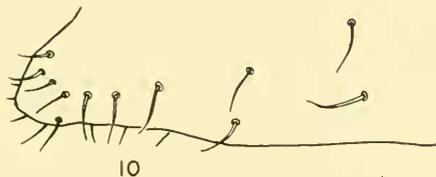
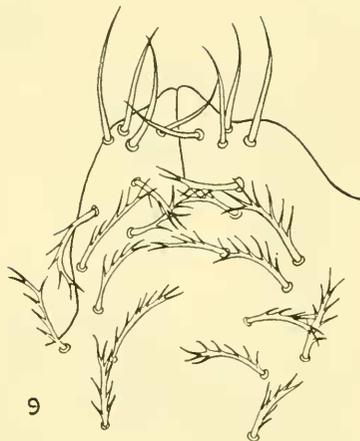


EXPLANATION OF FIGURES 8-15

Features of Nymphs. (Not to same scale.)

- Fig. 8. *Euschöngastoides loomisi*, hypostome.
Fig. 9. *Trombicula montanensis*, hypostome.
Fig. 10. *Cheladonta ouachitensis*, hypostome (lateral view).
Fig. 11. *Neoschöngastia brennani*, tip of hypostome.
Fig. 12. *Trombicula montanensis*, genitalia.
Figs. 13-15. *Trombicula splendens*, variations in branching of genital setae.

FIGURES 8-15

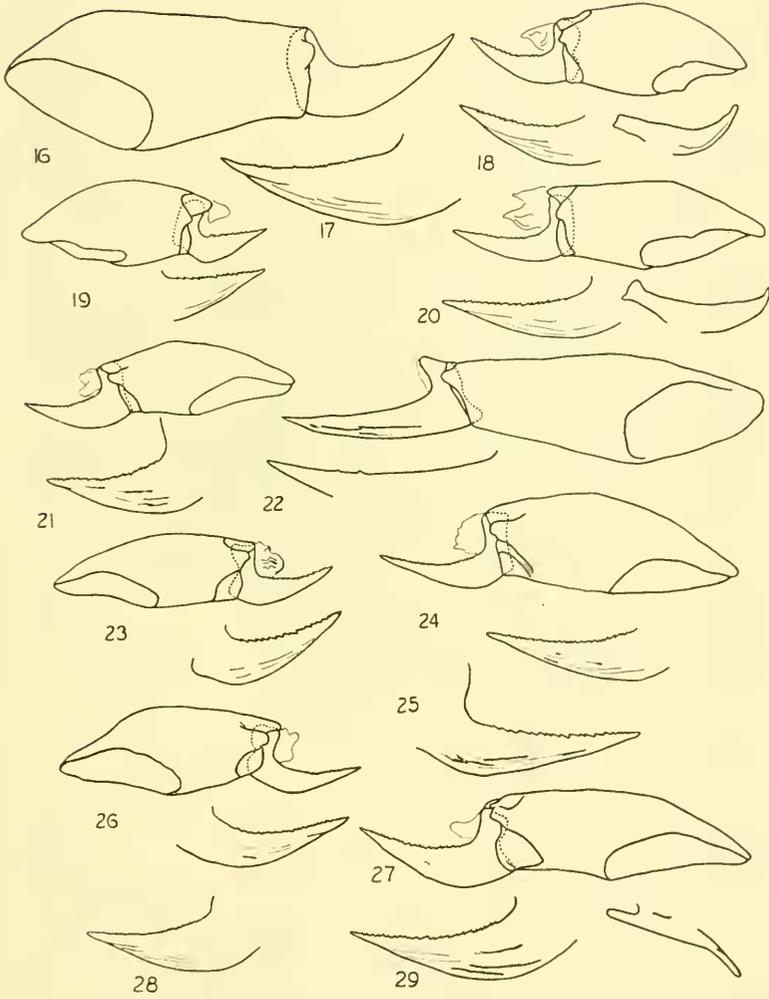


EXPLANATION OF FIGURES 16-29

Chelicerae of Nymphs. (Not to same scale.)

- Fig. 16. *Chatia setosa*, chelicera.
Fig. 17. *Chatia setosa*, cheliceral blade.
Fig. 18. *Leeuwenhoekia americana*, chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 19. *Hannemania multifemorala*, chelicera and cheliceral blade.
Fig. 20. *H. eltoni*, chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 21. *Trombicula alfreddugèsi*, chelicera and cheliceral blade.
Fig. 22. *Blankaartia alleei*, chelicera and cheliceral blade.
Fig. 23. *Trombicula belkini*, chelicera and cheliceral blade.
Fig. 24. *T. splendens*, chelicera and cheliceral blade.
Fig. 25. *T. lipovskyana*, cheliceral blade.
Fig. 26. *Euschöngastia jonesi*, chelicera and cheliceral blade.
Fig. 27. *E. setosa*, chelicera and cheliceral apodeme.
Fig. 28. *E. pipistrelli*, cheliceral blade.
Fig. 29. *E. setosa*, cheliceral blade.

FIGURES 16-29

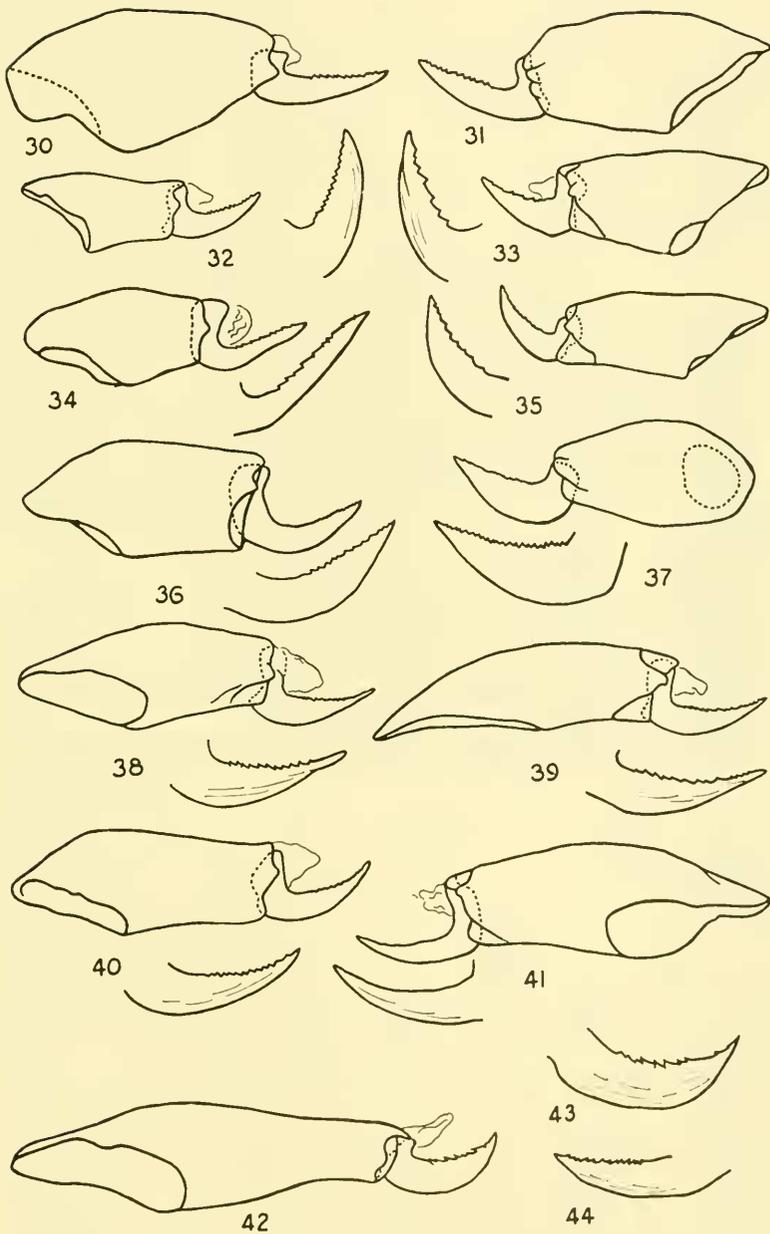


EXPLANATION OF FIGURES 30-44

Chelicerae of Nymphs. (To same scale except where indicated.)

- Fig. 30. *Euschöngastoides loomisi*, chelicera (not to scale).
Fig. 31. *E. hoplai*, chelicera (not to scale).
Fig. 32. *Pseudoschöngastia hungerfordi*, chelicera and cheliceral blade.
Fig. 33. *P. farneri*, chelicera and cheliceral blade.
Fig. 34. *Acomatacarus plumosus*, chelicera and cheliceral blade.
Fig. 35. *Walchia americana*, chelicera and cheliceral blade.
Fig. 36. *Whartonia senase*, chelicera and cheliceral blade.
Fig. 37. *Acomatacarus arizonensis*, chelicera and cheliceral blade.
Fig. 38. *Trombicula merrihewi*, chelicera and cheliceral blade.
Fig. 39. *Speleocola tadaridae*, chelicera and cheliceral blade.
Fig. 40. *Neoschöngastia americana*, chelicera and cheliceral blade.
Fig. 41. *N. brenmani*, chelicera and cheliceral blade.
Fig. 42. *Cheladonta micheneri*, chelicera.
Fig. 43. *C. micheneri*, cheliceral blade.
Fig. 44. *C. ouachitensis*, cheliceral blade.

FIGURES 30-44

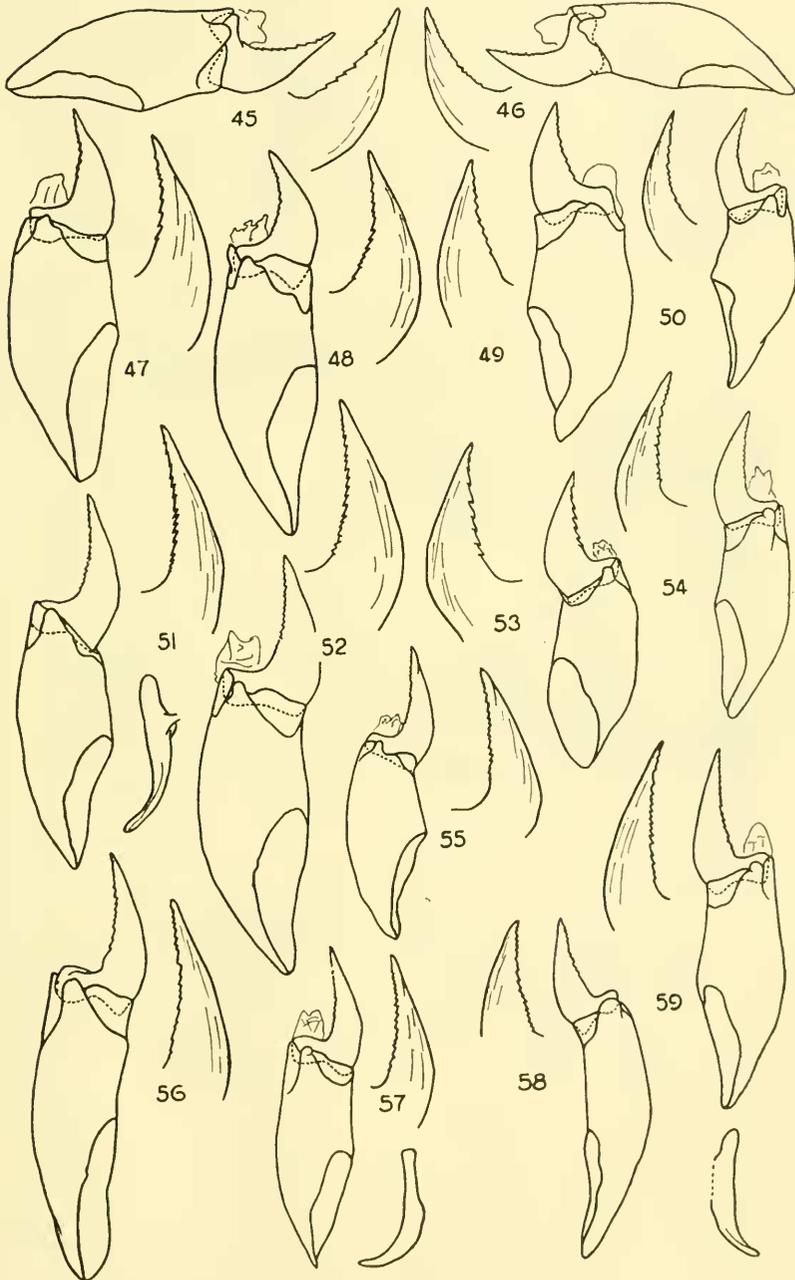


EXPLANATION OF FIGURES 45-59

Chelicerae of Nymphs. (To same scale.)

- Fig. 45. *Euschöngastia trigenuala*, chelicera and cheliceral blade.
Fig. 46. *E. criceticola*, chelicera and cheliceral blade.
Fig. 47. *E. pipistrelli*, chelicera and cheliceral blade.
Fig. 48. *E. peromysci*, chelicera and cheliceral blade.
Fig. 49. *E. diversa*, chelicera and cheliceral blade.
Fig. 50. *E. cynomyicola*, chelicera and cheliceral blade.
Fig. 51. *Trombicula whartoni*, chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 52. *T. autumnalis*, chelicera and cheliceral blade.
Fig. 53. *T. sylvilagi*, chelicera and cheliceral blade.
Fig. 54. *T. montanensis*, chelicera and cheliceral blade.
Fig. 55. *T. myotis*, chelicera and cheliceral blade.
Fig. 56. *T. kansasensis*, chelicera and cheliceral blade.
Fig. 57. *T. gurneyi*, chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 58. *T. ornata*, chelicera and cheliceral blade.
Fig. 59. *T. kardosi*, chelicera, cheliceral blade and cheliceral apodeme.

FIGURES 45-59



EXPLANATION OF FIGURES 60-73

Medial Views of Palpi of Nymphs.

(To same scale except where indicated.)

- Fig. 60. *Whartonia senase*.
- Fig. 61. *Hannemania eltoni* (not to scale).
- Fig. 62. *Lecuwenhoekia americana*.
- Fig. 63. *Blankaartia alleei* (not to scale).
- Fig. 64. *Euschöngastia jonesi*.
- Fig. 65. *E. setosa*.
- Fig. 66. *E. peromysci*.
- Fig. 67. *E. cynomyicola*.
- Fig. 68. *E. trigenuala*.
- Fig. 69. *Trombicula gurneyi*.
- Fig. 70. *Euschöngastia criceticola*.
- Fig. 71. *Neoschöngastia americana*.
- Fig. 72. *N. brennani*.
- Fig. 73. *Trombicula montanensis*.

FIGURES 60-73



EXPLANATION OF FIGURES 74-83

Medial Views of Palpi of Nymphs. (To same scale.)

- Fig. 74. *Trombicula alfreddugèsi*.
- Fig. 75. *T. splendens*.
- Fig. 76. *T. lipovskyana*.
- Fig. 77. *T. kansasensis*.
- Fig. 78. *T. kardosi*.
- Fig. 79. *T. belkini*.
- Fig. 80. *T. whartoni* (includes apical nude setae on tarsus).
- Fig. 81. *T. myotis*.
- Fig. 82. *T. autumnalis*.
- Fig. 83. *T. lipovskyi*.

FIGURES 74-83

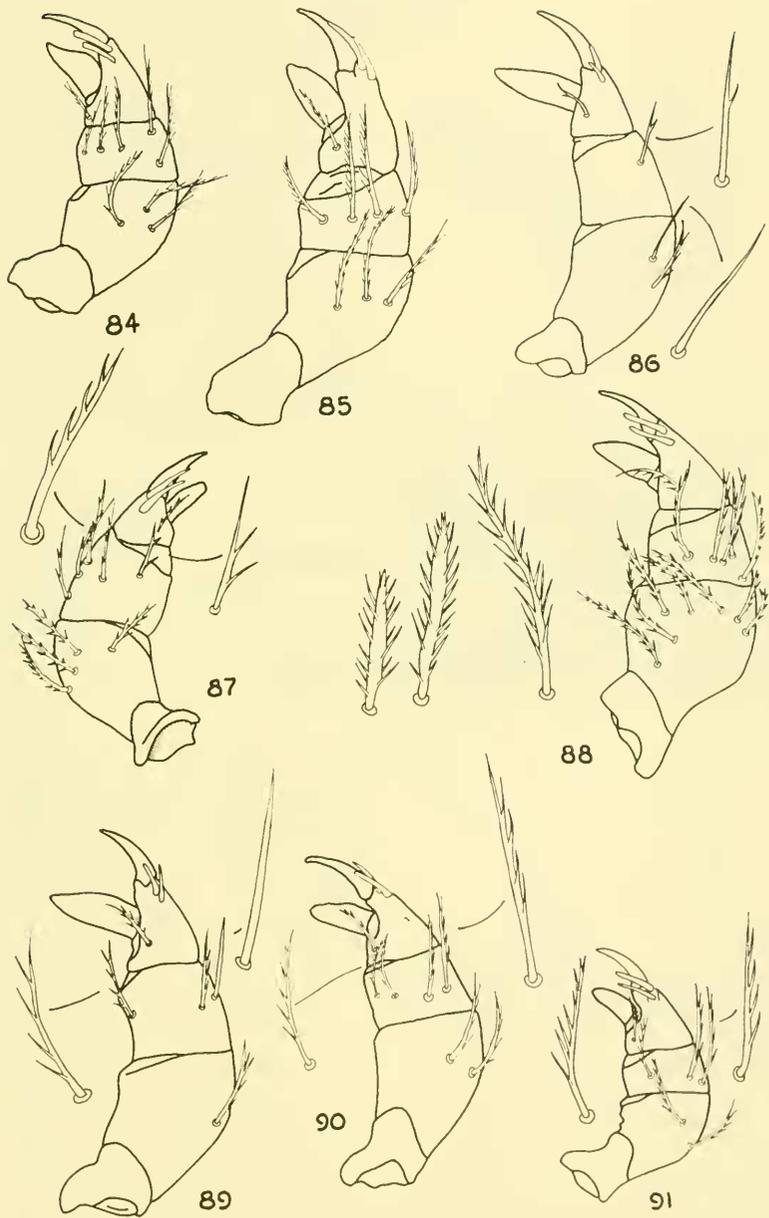


EXPLANATION OF FIGURES 84-91

Medial Views of Palpi of Nymphs. (To same scale.)

- Fig. 84. *Walchia americana*.
- Fig. 85. *Cheladonta micheneri*.
- Fig. 86. *Spelcocola tadaridae*.
- Fig. 87. *Euschöngastoides hoplai*.
- Fig. 88. *Acomatacarus plumosus* (including dorsal genual, dorsal femoral, and lateral femoral seta).
- Fig. 89. *Trombicula merrihewi*.
- Fig. 90. *Pseudoschöngastia farneri*.
- Fig. 91. *P. hungerfordi*.

FIGURES 84-91

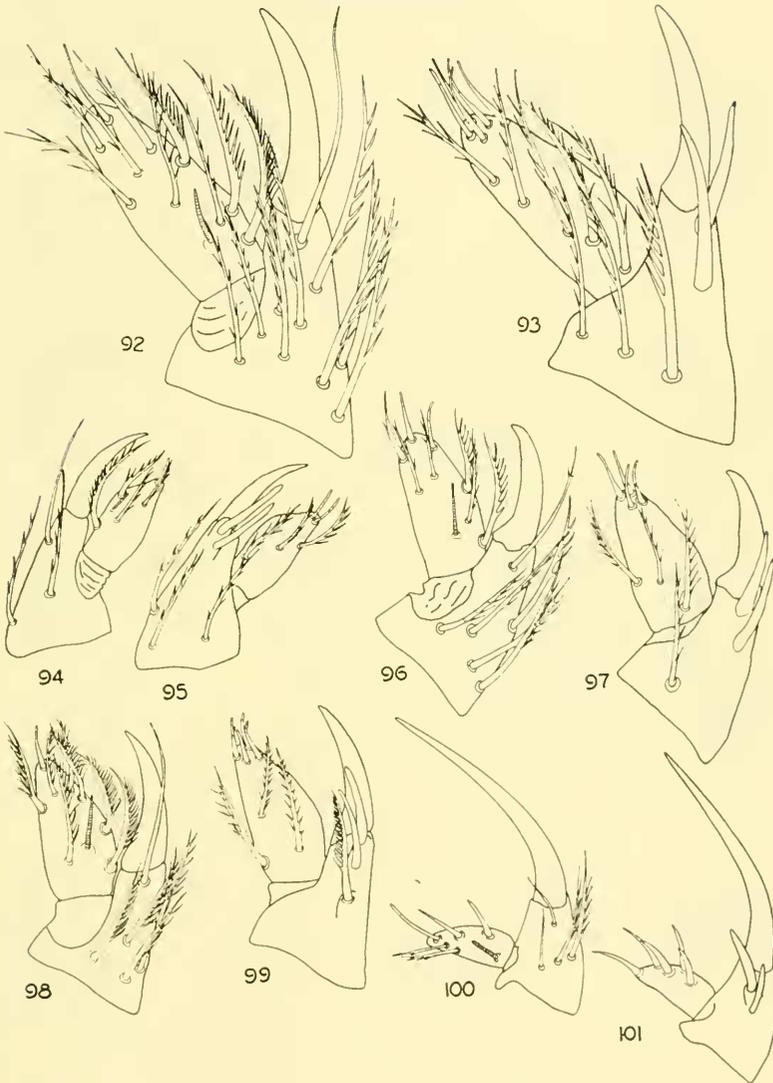


EXPLANATION OF FIGURES 92-101

Palpal Tibiotarsi of Nymphs. (To same scale.)

- Fig. 92. *Chatia setosa*, lateral view.
- Fig. 93. *C. setosa*, medial view.
- Fig. 94. *Whartonia senase*, lateral view.
- Fig. 95. *W. senase*, medial view.
- Fig. 96. *Leeuwenhoekia americana*, lateral view.
- Fig. 97. *L. americana*, medial view.
- Fig. 98. *Hannemania eltoni*, lateral view.
- Fig. 99. *H. eltoni*, medial view.
- Fig. 100. *Neoschöngastia brennani*, lateral view.
- Fig. 101. *N. brennani*, medial view.

FIGURES 92-101



EXPLANATION OF FIGURES 102-117

Palpal Tibiotarsi of Nymphs. (To same scale.)

- Fig. 102. *Euschöngastia setosa*, lateral view.
- Fig. 103. *E. setosa*, medial view.
- Fig. 104. *E. peromysci*, lateral view.
- Fig. 105. *E. peromysci*, medial view.
- Fig. 106. *Trombicula myotis*, lateral view.
- Fig. 107. *T. myotis*, medial view.
- Fig. 108. *E. jonesi*, lateral view.
- Fig. 109. *E. jonesi*, medial view.
- Fig. 110. *Trombicula alfreddugèsi*, lateral view.
- Fig. 111. *T. alfreddugèsi*, medial view.
- Fig. 112. *T. gurneyi*, lateral view.
- Fig. 113. *T. gurneyi*, medial view.
- Fig. 114. *T. kansasensis*, lateral view.
- Fig. 115. *T. kansasensis*, medial view.
- Fig. 116. *T. lipovskyi*, lateral view.
- Fig. 117. *T. lipovskyi*, medial view.

FIGURES 102-117

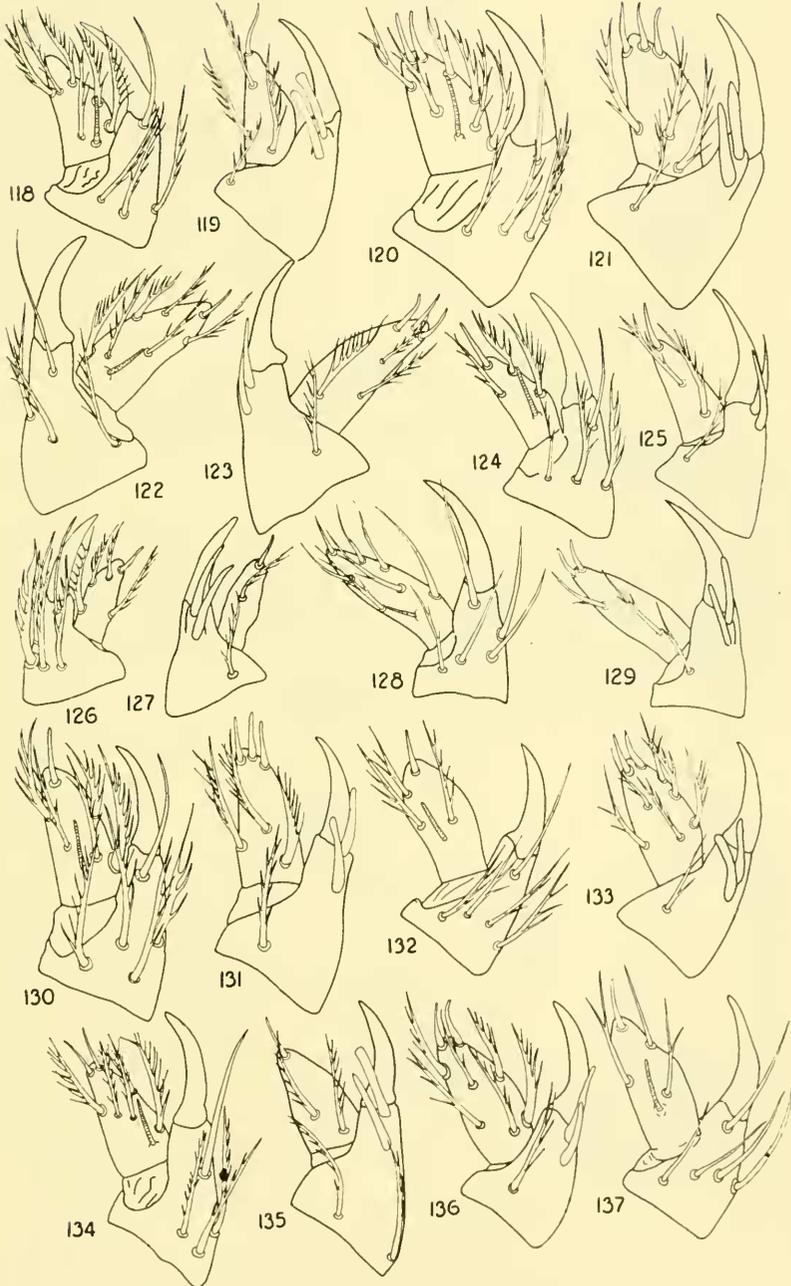


EXPLANATION OF FIGURES 118-137

Palpal Tibiotarsi of Nymphs. (To same scale.)

- Fig. 118. *Walchia americana*, lateral view.
- Fig. 119. *W. americana*, medial view.
- Fig. 120. *Euschöngastia trigenuala*, lateral view.
- Fig. 121. *E. trigenuala*, medial view.
- Fig. 122. *Trombicula montanensis*, lateral view.
- Fig. 123. *T. montanensis*, medial view.
- Fig. 124. *Pseudoschöngastia farneri*, lateral view.
- Fig. 125. *P. farneri*, medial view.
- Fig. 126. *Euschöngastoides hoplai*, lateral view.
- Fig. 127. *E. hoplai*, medial view.
- Fig. 128. *Speleocola tadaridae*, lateral view.
- Fig. 129. *S. tadaridae*, medial view.
- Fig. 130. *Euschöngastia criceticola*, lateral view.
- Fig. 131. *E. criceticola*, medial view.
- Fig. 132. *Trombicula crossleyi*, lateral view.
- Fig. 133. *T. crossleyi*, medial view.
- Fig. 134. *Acomatacarus plumosus*, lateral view.
- Fig. 135. *A. plumosus*, medial view.
- Fig. 136. *Trombicula merrihewi*, lateral view.
- Fig. 137. *T. merrihewi*, medial view.

FIGURES 118-137

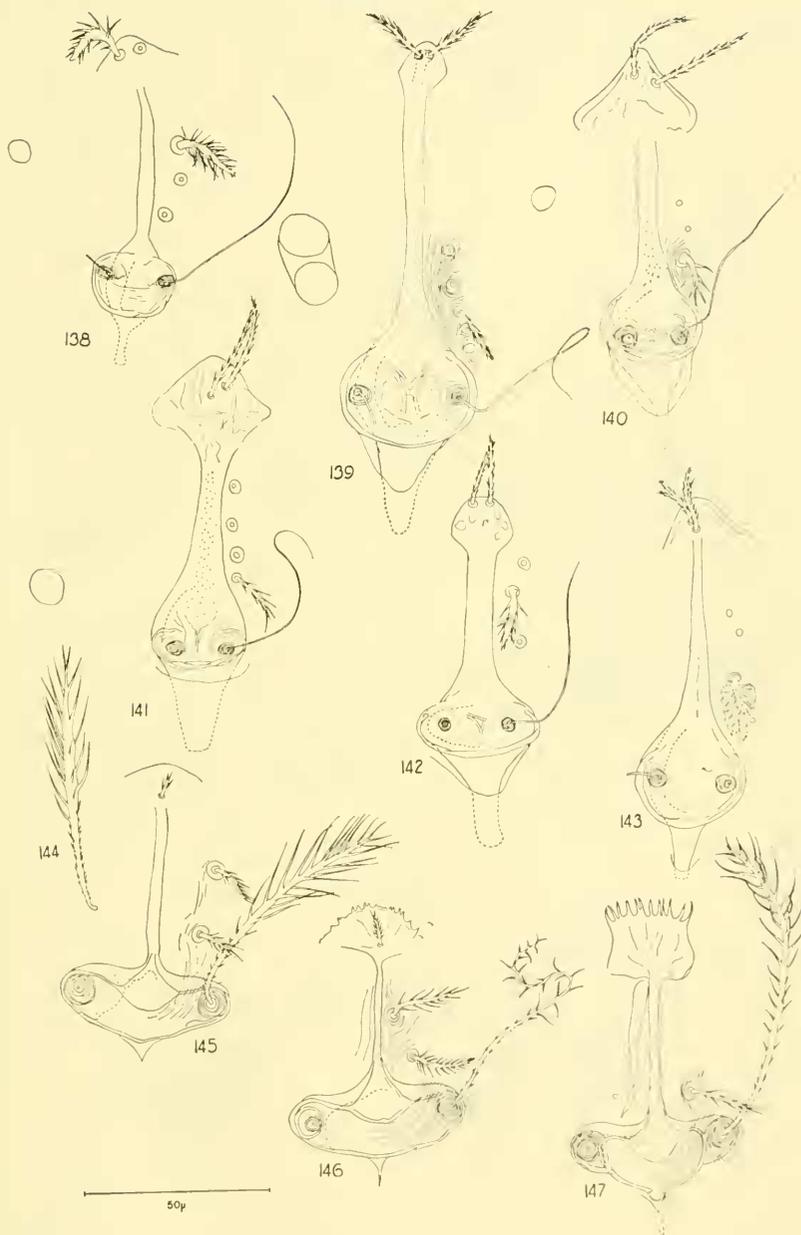


EXPLANATION OF FIGURES 138-147

Scuta of Nymphs. (To same scale except where indicated.)

- Fig. 138. *Acomatacarus plumosus*.
- Fig. 139. *Hannemania eltoni*.
- Fig. 140. *Leeuwenhoekia americana*.
- Fig. 141. *Chatia setosa*.
- Fig. 142. *Acomatacarus arizonensis* (not to same scale).
- Fig. 143. *Whartonia senase*.
- Fig. 144. *Pseudoschöngastia hungerfordi* (sensillum).
- Fig. 145. *P. farneri* (not to same scale).
- Fig. 146. *Euschöngastoides hoplai*.
- Fig. 147. *Walchia americana* (not to same scale).

FIGURES 138-147

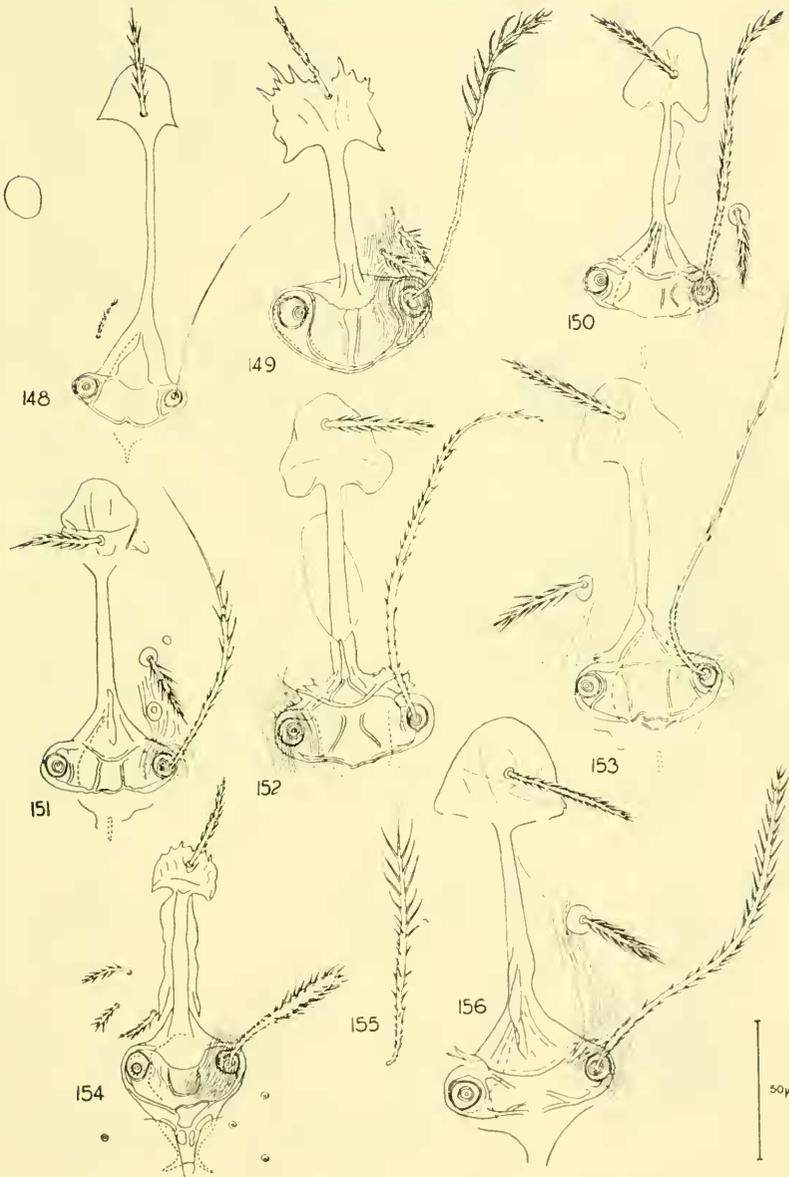


EXPLANATION OF FIGURES 148-156

Scuta of Nymphs. (To same scale except where indicated.)

- Fig. 148. *Blankaartia velascoi* (not to same scale).
- Fig. 149. *Neoschöngastia brennani*.
- Fig. 150. *Euschöngastia criceticola*.
- Fig. 151. *E. trigenuala*.
- Fig. 152. *E. peromysci*.
- Fig. 153. *E. jonesi*.
- Fig. 154. *Cheladonta micheneri*.
- Fig. 155. *C. ouachitensis* (sensillum).
- Fig. 156. *Euschöngastia setosa*.

FIGURES 148-156

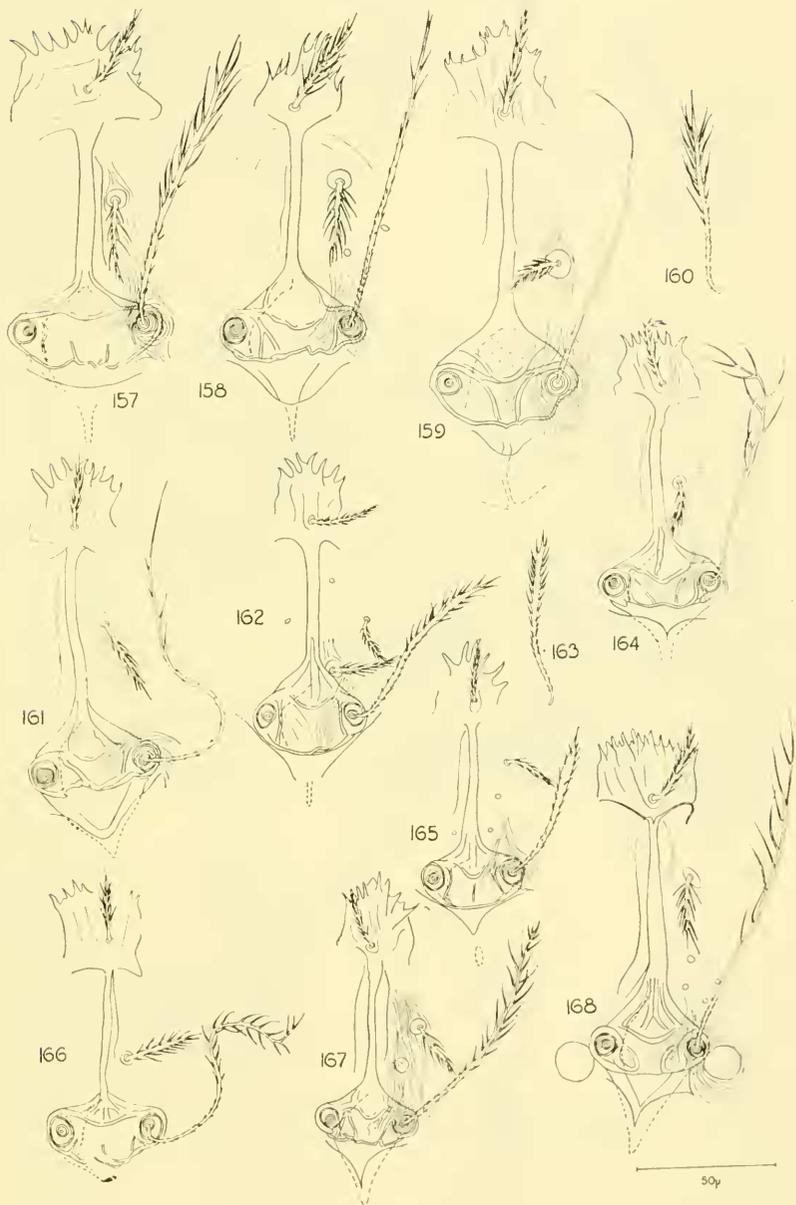


EXPLANATION OF FIGURES 157-168

Scuta of Nymphs. (to same scale except where indicated.)

- Fig. 157. *Trombicula autumnalis* (not to same scale).
- Fig. 158. *T. lipovskyi*.
- Fig. 159. *T. whartoni*.
- Fig. 160. *T. sylvilagi* (sensillum).
- Fig. 161. *T. kardosi*.
- Fig. 162. *T. ornata*.
- Fig. 163. *T. crossleyi* (sensillum).
- Fig. 164. *T. gurneyi*.
- Fig. 165. *T. merrihewi*.
- Fig. 166. *T. myotis*.
- Fig. 167. *T. montanensis*.
- Fig. 168. *T. alfreddugèsi*.

FIGURES 157-168

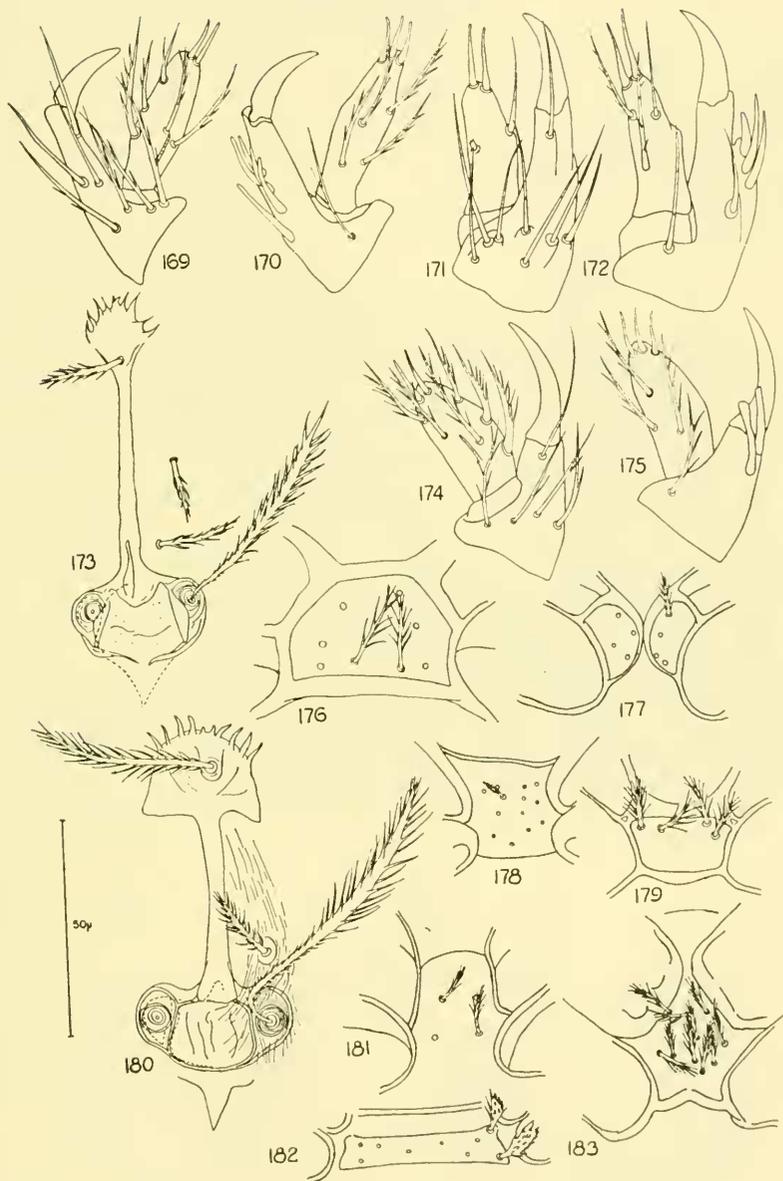


EXPLANATION OF FIGURES 169-183

Features of Nymphs. (Not to same scale.)

- Fig. 169. *Blankartia velascoi*, lateral view of palpal tibiotarsus.
Fig. 170. *B. velascoi*, medial view of palpal tibiotarsus.
Fig. 171. *B. alleci*, lateral view of palpal tibiotarsus.
Fig. 172. *B. alleci*, medial view of palpal tibiotarsus.
Fig. 173. *Speleocola tadaridae*, scutum.
Fig. 174. *Trombicula kardosi*, lateral view of palpal tibiotarsus.
Fig. 175. *T. kardosi*, medial view of palpal tibiotarsus.
Fig. 176. *T. splendens*, sternum.
Fig. 177. *Neoschöngastia americana*, sternum.
Fig. 178. *Hannemania multifemorala*, sternum.
Fig. 179. *Euschöngastoides hoplai*, sternum.
Fig. 180. *Neoschöngastia americana*, scutum.
Fig. 181. *Trombicula merrihewi*, sternum.
Fig. 182. *Whartonia senase*, sternum.
Fig. 183. *Cheladonta micheneri*, sternum.

FIGURES 169-183

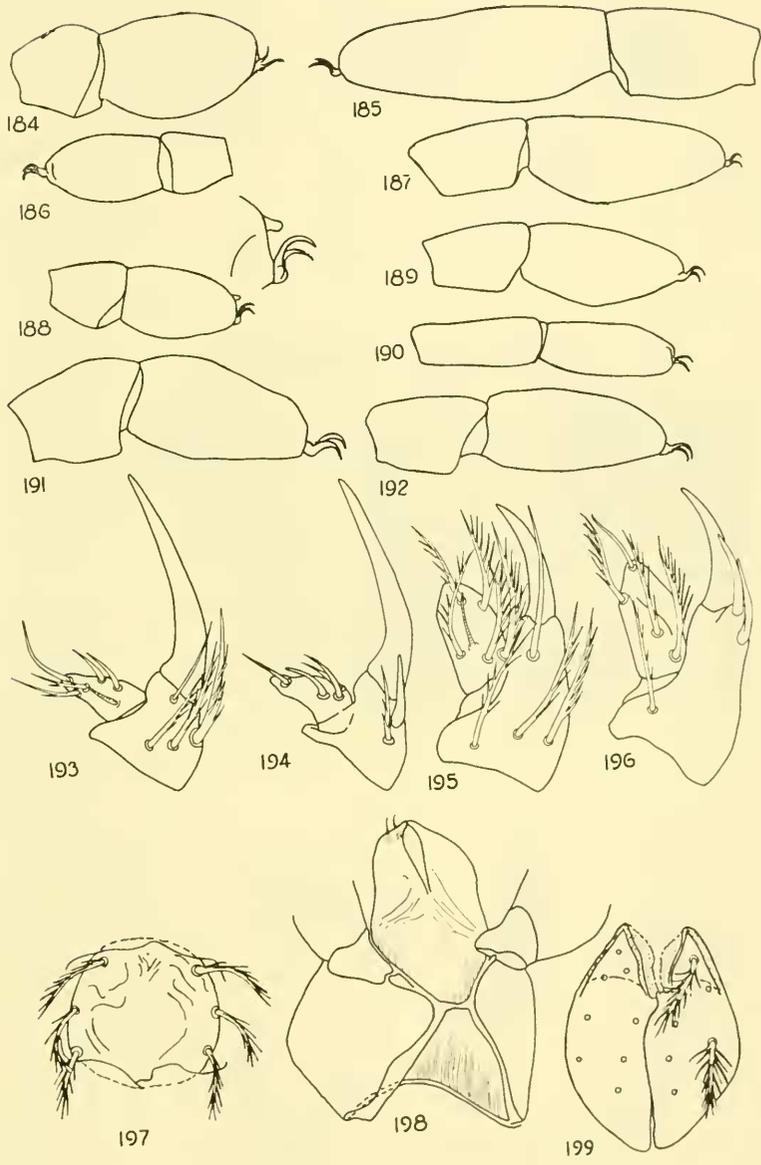


EXPLANATION OF FIGURES 184-199

Features of Nymphs. (Not to same scale.)

- Fig. 184. *Cheladonta micheneri*, tibia and tarsus of leg I.
Fig. 185. *Leeuwenhoekia americana*, tibia and tarsus of leg I.
Fig. 186. *Euschöngastoides hoplai*, tibia and tarsus of leg I.
Fig. 187. *Whartonia senase*, tibia and tarsus of leg I.
Fig. 188. *Walchia americana*, tibia and tarsus of leg I.
Fig. 189. *Acomatacarus plumosus*, tibia and tarsus of leg I.
Fig. 190. *Chatia setosa*, tibia and tarsus of leg I.
Fig. 191. *Trombicula alfreddugèsi*, tibia and tarsus of leg I.
Fig. 192. *Euschöngastia trigenuala*, tibia and tarsus of leg I.
Fig. 193. *Neoschöngastia americana*, lateral view of palpal tibiotarsus.
Fig. 194. *N. americana*, medial view of palpal tibiotarsus.
Fig. 195. *Cheladonta micheneri*, lateral view of palpal tibiotarsus.
Fig. 196. *C. micheneri*, medial view of palpal tibiotarsus.
Fig. 197. *Leeuwenhoekia americana*, anus.
Fig. 198. *Trombicula tricetica*, dorsal view of basis capituli and hypostome (palpi still articulated at sides but chelicerae removed).
Fig. 199. *Trombicula splendens*, anus.

FIGURES 184-199

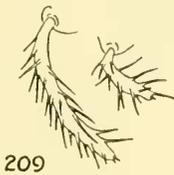
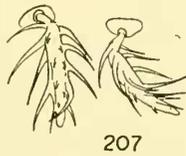
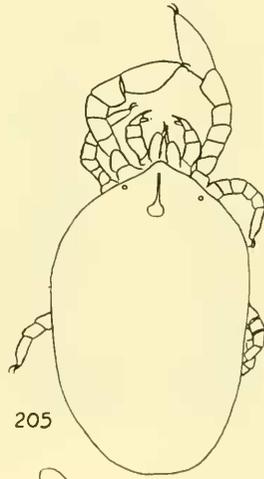
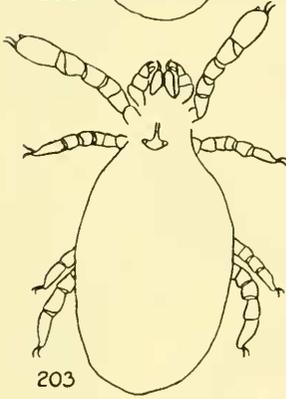
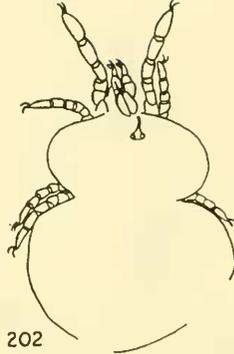
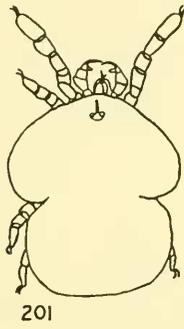
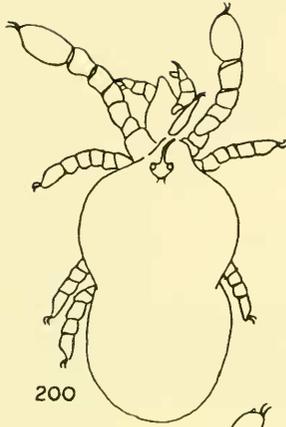


EXPLANATION OF FIGURES 200-210

Features of Nymphs. (Not to same scale.)

- Fig. 200. *Cheladonta ouachitensis*, dorsal outline of body.
- Fig. 201. *Neoschöngastia americana*, dorsal outline of body.
- Fig. 202. *Trombicula ornata*, dorsal outline of body.
- Fig. 203. *Walchia americana*, dorsal outline of body.
- Fig. 204. *Hannemania dunni*, posterior body seta.
- Fig. 205. *Acomatacarus plumosus*, dorsal outline of body.
- Fig. 206. *Blankaartia velascoi*, posterior body seta.
- Fig. 207. *Acomatacarus plumosus*, posterior body seta.
- Fig. 208. *Blankaartia alleei*, posterior body seta.
- Fig. 209. *Acomatacarus arizonensis*, posterior body seta.
- Fig. 210. *Chatia setosa*, posterior body seta.

FIGURES 200-210



EXPLANATION OF FIGURES 211-225

Posterior Body Setae of Nymphs. (To same scale except where indicated.)

Fig. 211. *Euschöngastia peromysci* (tip) (Tennessee variant).

Fig. 212. *E. cynomyicola* (tip).

Fig. 213. *E. setosa* (tip).

Fig. 214. *E. peromysci* (tip) (Kansas variant).

Fig. 215. *E. diversa* (tip).

Fig. 216. *E. jonesi* (tip).

Fig. 217. *E. criceticola*.

Fig. 218. *Pseudoschöngastia hungerfordi*.

Fig. 219. *Euschöngastoides hoplai*.

Fig. 220. *Euschöngastia trigenuala*.

Fig. 221. *Cheladonta ouachitensis*.

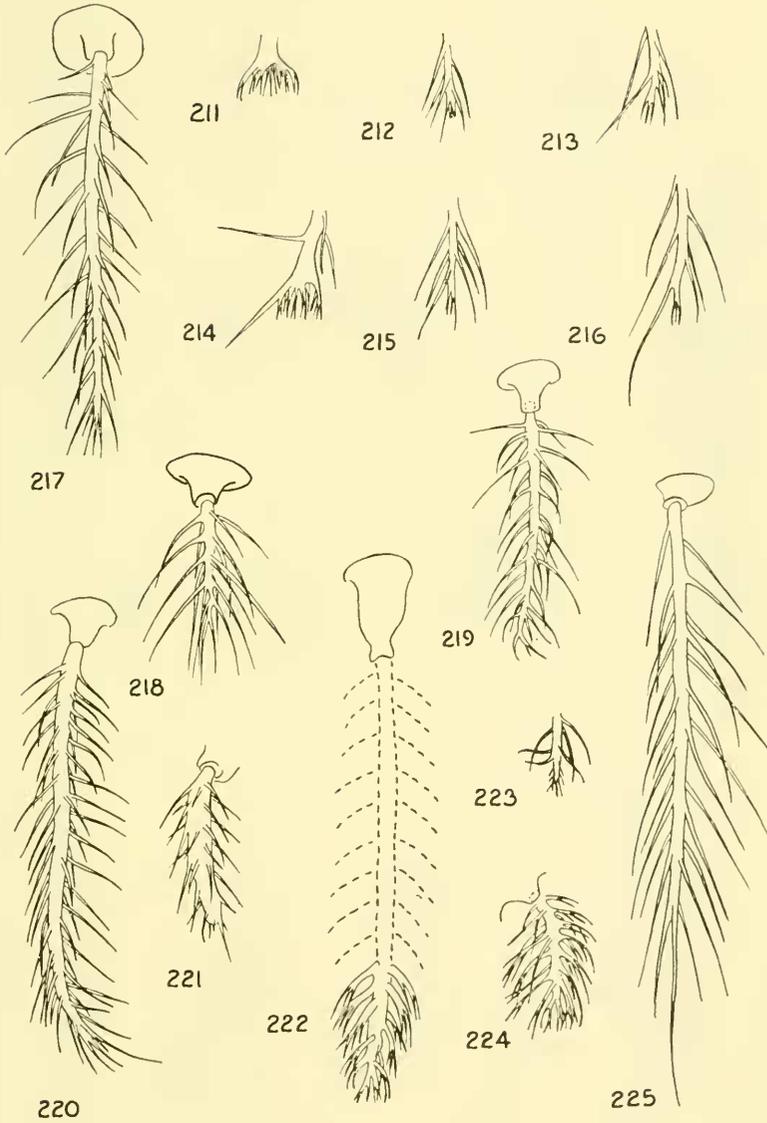
Fig. 222. *Neoschöngastia americana* (long seta).

Fig. 223. *Euschöngastoides loomisi* (tip).

Fig. 224. *Neoschöngastia americana* (short seta).

Fig. 225. *Euschöngastia pipistrelli* (not to same scale).

FIGURES 211-225



EXPLANATION OF FIGURES 226-240

Posterior Body Setae of Nymphs. (To same scale except where indicated.)

Figs. 226-227. *Trombicula alfreddugèsi*.

Fig. 228. *T. splendens* (tip).

Fig. 229. *T. belkini*.

Fig. 230. *T. fitchi* (not to scale).

Fig. 231. *T. myotis*.

Fig. 232. *T. merrihewi*.

Fig. 233. *Speleocola tadaridae*.

Fig. 234. *Whartonia senase*.

Fig. 235. *Walchia americana*.

Fig. 236. *Trombicula autumnalis*.

Fig. 237. *T. sylvilagi*.

Fig. 238. *T. gurneyi*.

Fig. 239. *T. montanensis*.

Fig. 240. *T. lipovskyi*.

FIGURES 226-240

